SWEEP

SOIL AND WATER

ENVIRONMENTAL

ENHANCEMENT PROGRAM

PAMPA

PROGRAMME D'AMELIORATION

DU MILIEU PEDOLOGIQUE

ET AQUATIQUE

Canada

Ontario

SWEEP

is a $30 million federal-provincial agreement, announced May 8, 1986, designed to improve soil and water quality in southwestern Ontario over the next five years.

PURPOSES

There are two interrelated purposes to the program; first, to reduce phosphorus loadings in the Lake Erie basin from cropland run-off; and second, to improve the productivity of southwestern Ontario agriculture by reducing or arresting soil erosion that contributes to water pollution.

BACKGROUND

The Canada-U.S. Great Lakes Water Quality Agreement called for phosphorus reductions in the Lake Erie basin of 2000 tonnes per year. SWEEP is part of the Canadian agreement, calling for reductions of 300 tonnes per year — 200 from croplands and 100 from industrial and municipal sources.

PAMPA

est une entente fédérale-provinciale de 30 millions de dollars, annoncée le 8 mai 1986, et destinée à améliorer la qualité du sol et de l'eau dans le Sud-ouest de l'Ontario.

SES BUTS

Les deux buts de PAMPA sont: en premier lieu de réduire de 200 tonnes par an d'ici 1990 le déversement dans le lac Erie de phosphore provenant des terres agricoles, et de maintenir ou d'accroître la productivité agricole du Sud-ouest de l'Ontario, en réduisant ou en empêchant l'érosion et la dégradation du sol.

SES GRANDES LIGNES

L'entente entre le Canada et les États-Unis sur la qualité de l'eau des Grands Lacs prévoyait de réduire de 2 000 tonnes par an la pollution due au phosphore dans le bassin du lac Erie. PAMPA fait partie de cette entente qui réduira cette pollution de 300 tonnes par an — 200 tonnes provenant des terres agricoles et 100 tonnes provenant de sources industrielles et municipales.

100-05235/

TECHNOLOGY EVALUATION AND DEVELOPMENT SUB-PROGRAM

APPENDIX 1 - 4
STUDIES ON THE CONTROL OF PROBLEM WEED SPECIES IN CONSERVATION TILLAGE SYSTEMS

FINAL REPORT

September, 1990

Up to Page 106 - Complete report goes to P. 239 (pp. 107-239 consists of Tables A1-A69).

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Disclaimer: The views contained herein do not necessarily reflect the views of the Government of Canada or the SWEEP Management Committee.

The contents of this Appendix are also published under the Weed Survey Series Publication 90-1, Agriculture Canada, November, 1990 entitled, "Weeds of Corn, Soybean, and Winter Wheat Fields Under Conventional, Conservation, and No-Till Management Systems in Southwestern Ontario. 1988 and 1989."

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SERIES FOREWORD

This publication is part of a continuing series which presents the information accumulated during recent weed survey projects in Canada. The published reports to date have dealt with cereal and/or oilseed crops in Prince Edward Island, Manitoba, Saskatchewan, Alberta, and the Peace River Region of British Columbia. Reports for Essex and Kent Counties of Ontario included row crops (corn, soybean, and tomato) in addition to cereal crops. Weeds of forage fields in the Peace River Region of British Columbia and weeds of alfalfa seed grower fields in Manitoba were also the subjects of reports in this series. Two recent publications in this series reported on surveys of the special crops, sunflower, mustard, lentil and dry pea in Saskatchewan. In 1985, winter wheat was added to the growing list of crops surveyed in Saskatchewan. All surveys have used a standardized methodology that enables the results from across Canada to be assessed in the same way. The study reported in this publication is the first in the Weed Survey Series to include the results of a comparison among the weed populations under different tillage systems in addition to comparisons among different crops and geographic regions.

The principal objectives of these surveys are to document the size and extent of weed populations in agricultural ecosystems, to document the geographic distribution of individual species in the weed flora, and to provide quantitative data that could be used to estimate losses due to weeds. As well as providing the baseline information for future comparisons, the data can be used now to pinpoint major weed problems that require specific research, industry and extension activity.

The specific goal of the field survey component is to identify and quantify the weed problems which exist in fields at the present time. Surveys are conducted for two or more consecutive years. Fields must be surveyed for at least two years and the results pooled to minimize the influence of seasonal variation in the weed and crop environment. A common question asked of weed researchers is whether or not the species composition and density of the weed flora of a crop has changed over a period of years because of changes in management practices. Thus, surveys are needed to document the weed picture at periodic intervals so that these comparisons can be made. The establishment of a database to which future survey results can be compared is a logical first step. Consecutive annual surveys can rarely be used to determine trends in weed distribution and abundance because shifts in weed

populations occur relatively slowly. For this reason the initial series of annual surveys should be followed by a second series conducted after approximately a five year interval. These two series are required to document any significant shifts in weed population levels. Saskatchewan and Manitoba were surveyed again in 1986 to measure the changes that had occurred in the weed populations and these results have been reported in publications of this series.

The specific goal of the questionnaire survey component is to identify specific agronomic practices currently being used by the farm community which may be influencing the nature of the weed infestations found in the field survey component. The questionnaire is an integral part of all weed survey projects. Supplementary information on cropping history, crop production, and weed control is obtained in the questionnaire from the person who farmed the selected field. The questionnaire information is important for a proper interpretation of the weed problems facing growers.

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PREFACE

Soil erosion is a serious environmental and agricultural concern. In 1984, sheet and rill erosion cost Ontario farmers $68 million in yield reduction, nutrient loss, and pesticide loss (Standing committee on Agriculture, Fisheries, and Forestry 1984). The nutrients and pesticides contained in cropland runoff make it a significant source of water pollution.

This study was funded by the Technology Evaluation and Development (TED) subprogram of the Soil and Water Environmental Enhancement Program (SWEEP) through a contract with Southwestern Ontario Agricultural Research Corporation. SWEEP is a joint federal-provincial (Ontario) program designed to reduce soil erosion and runoff from cropland and to improve agricultural productivity by controlling soil degradation in southwestern Ontario. The TED subprogram of SWEEP is directed at field level evaluation of technologies which contribute to these goals.

The report is divided into three major sections and an appendix. The first section is a general introduction to the report. The field survey for weeds is presented in the second section. The third section contains the results of the questionnaire survey. Discussion and conclusion chapters at the end of the second and third sections highlight the significant results obtained. The appendix contains the field survey summary tables. The summary tables have the same format as others in the Weed Survey Series.

The 1988 field data were collected by myself and T. Hawkes. The 1989 field data were collected by T. Hawkes, E. Schuster, and M. Padoin. Questionnaires were completed for each field surveyed. T. Hawkes and I completed the questionnaires by telephone interview in 1988; E. Schuster completed the questionnaires by both personal and telephone interview in 1989. I would like to thank all who were involved for their dedication and hard work.

I would also like to thank the 59 farm operators who allowed us to count weeds in their crops in the 1988 season, and the 100 operators who did so in 1989. Many of the names of growers were provided by OMAF conservation advisors, soil and crop advisors, and Conservation Authority personnel. I thank them for their co-operation.

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I. INTRODUCTION

Background

Conservation tillage has been defined as any method of tillage which leaves a minimum of 30% plant residue on the soil surface. Such systems include no-till and various systems which reduce the number of tillages, or use different types of tillage equipment other than the moldboard plow. Adoption of conservation tillage systems in agriculture could significantly reduce erosion, soil degradation, and water pollution. One of the main obstacles to widespread adoption of conservation tillage is the perception by farmers that new and exacerbated weed problems will occur when tillage is no longer available as a method of weed control.

Weed communities reflect farm management systems. As farm management systems change, for instance from conventional to conservation tillage, weed species composition and weed densities may change. Differences in the timing of weed emergence or in the rate of growth of weeds may also occur, which in turn will affect the success of weed management measures.

The transitional period during the conversion from conventional to conservation tillage may be particularly problematic, because the weed community is undergoing change. Weed problems may include those of both management systems. Conventional weed control practices must be adapted to new management systems.

Previous surveys

Quantitative weed survey data are unavailable for most crops and regions in Ontario but a few studies have provided some information. Data on the distribution and abundance of weeds occurring in tomato and sweet corn fields of Essex, Kent, and Prince Edward Counties were published in 1964 by J. F. Alex (Weed Research 4:308-318). Corn, soybean, white bean, and mixed grain fields in Kent, Middlesex, and Perth Counties were surveyed by R. A. Richards (M.Sc. Thesis, University of Guelph, 1979). A survey of corn, soybean, cereal, and tomato fields in Essex and Kent Counties was also organized by A. S. Hamill during 1978 and 1979 (Publications 83-1 and 83-2 in the Weed Survey Series). In all these studies, only a small proportion of the province was included. Conventional tillage systems were assumed to have been used in these surveyed fields. Up-to-date quantitative data on weed populations under various tillage regimes throughout southern Ontario are needed.

Objective

The primary goal of the weed survey project, which is reported in this publication, is the identification of weed species likely to be the greatest problems under various tillage systems in southwestern Ontario. Information on the response of the weed community to changes in tillage practices is vital for a sensible farm management program. As well as the field survey for weeds, data on farm management practices were gathered through a questionnaire. This report is a summary of the results from 1988 and 1989.

Survey Area

The survey area is bounded by Lake Erie on the south and by the Detroit River, Lake St. Clair, St. Clair River, and Lake Huron on the west (Figure 1). The area extends north and east to 44° N latitude and to 80° W longitude. This southwestern corner of Ontario is part of the West St. Lawrence Lowland physiographic subdivision of Canada. All the area has been subjected to glacial erosion and deposition during the Pleistocene. Soils in the region are luvisols and gleysols, ranging in texture from sandy loam to clay, and formed on glacial till or lacustrine deposits. The topography varies from very gently undulating to rolling with elevations ranging from 175 m above sea level along Lake Erie to 500 m on the northern limit of the study area.

The survey included 11 counties of Southwestern Ontario that are especially prone to soil erosion. These counties cover the watersheds of the west branch of the Hillman Creek, the Big Creek tributary of the Thames River, the Upper Little Ausable River, a tributary of the Maitland River, and Holiday Creek (Figure 2). These watersheds have erosion indices in access of 3 ton/ha/yr and are considered to be of high to medium erosion potential (L.J.P. Van Vliet, G.J. Wall, and W. T. Dickinson. 1978. Agricultural Watershed Studies).

The July mean temperature in the study area is 21 C and the January mean is -4 C. Mean annual minimum and maximum temperatures are -12 C and 35 C respectively. Corn heat units for the area range from 2300 to 3700. The mean annual total precipitation varies from 750 mm in the southwest to 950 mm in the north with a seasonal (May to September) potential evapotranspiration of approximately 500 mm in the study area. The annual frost-free season ranges from 150 days in the north to 180 days in the south.

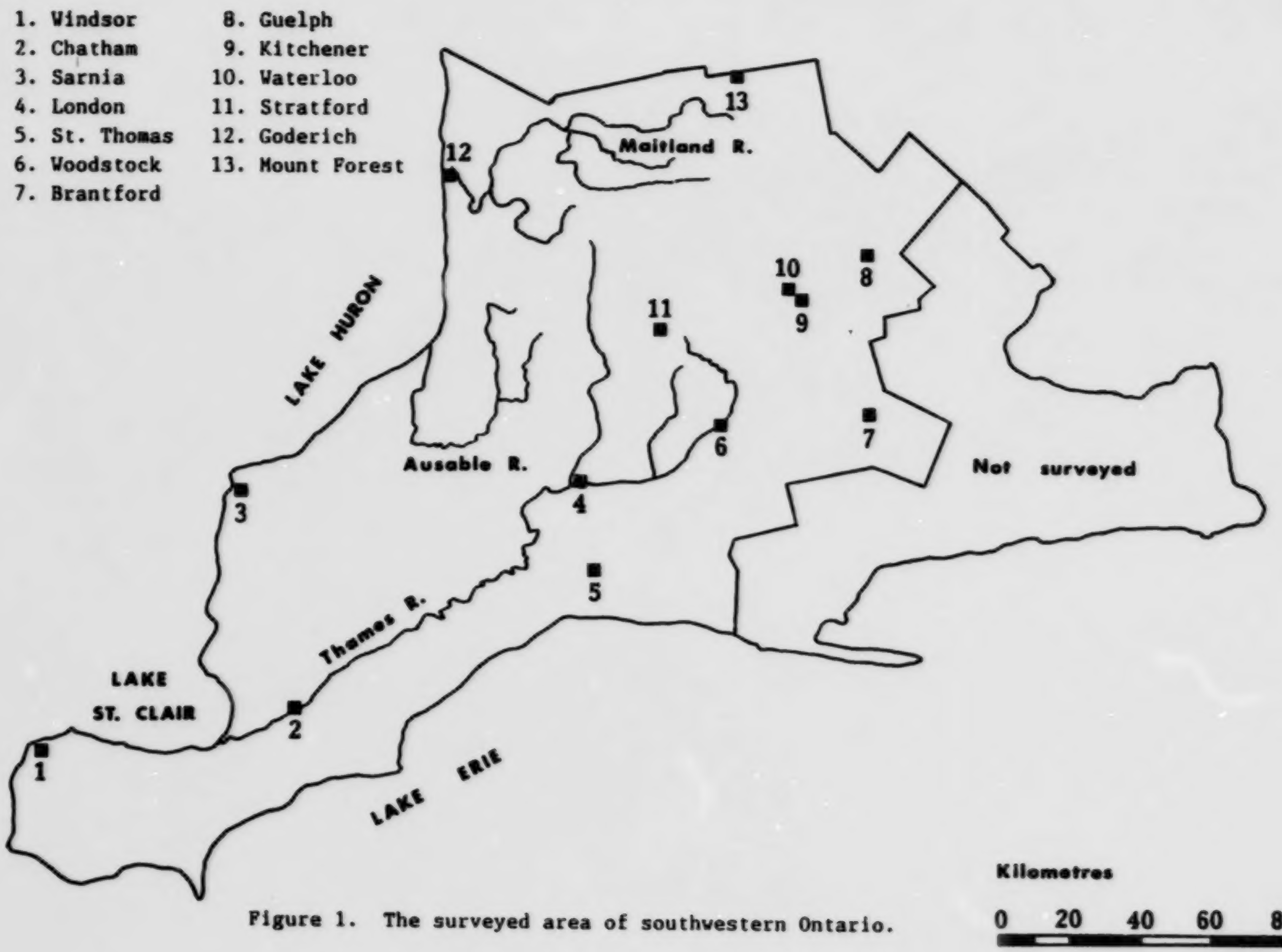

Figure 1. The surveyed area of southwestern Ontario.

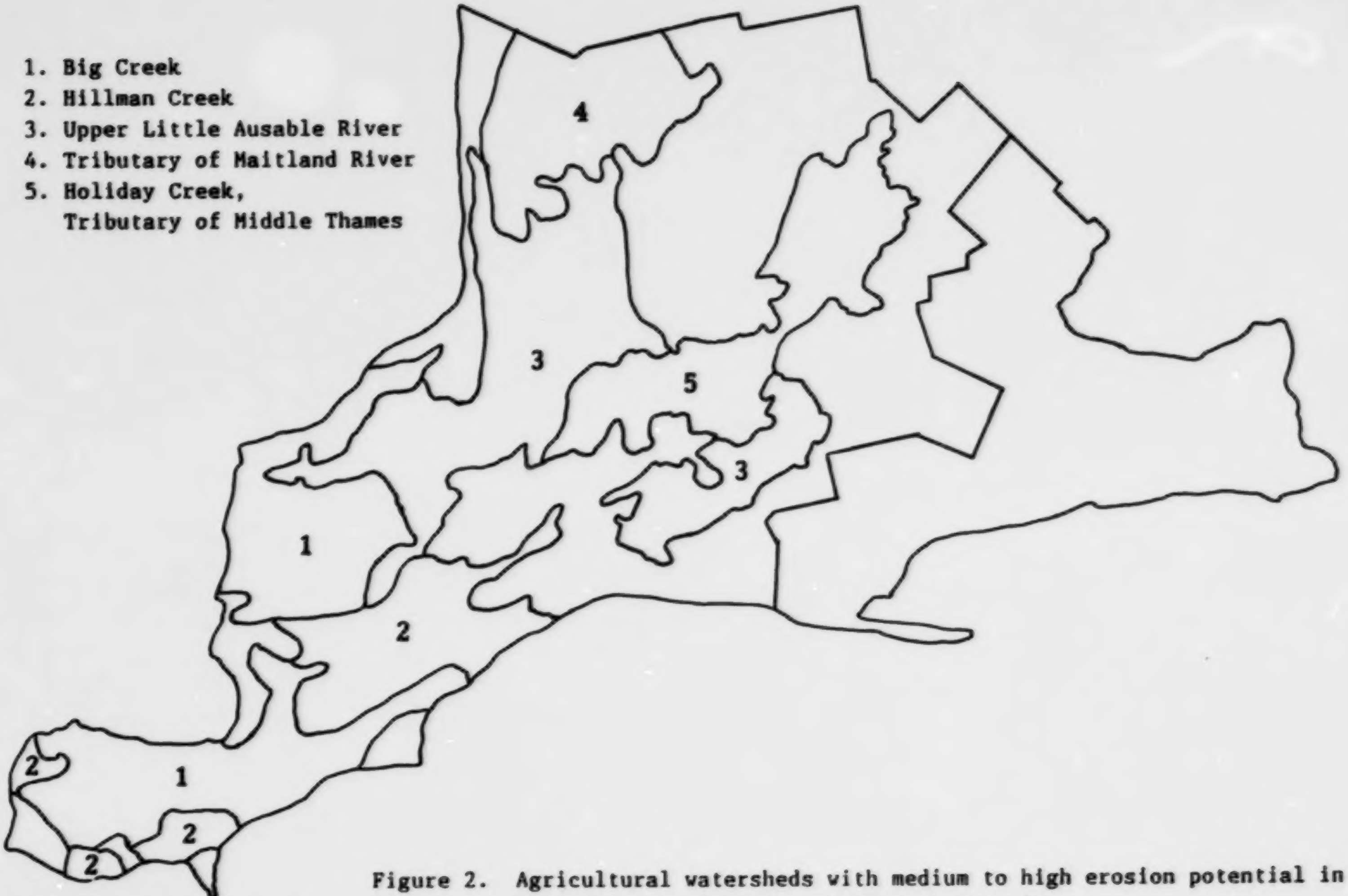

Figure 2. Agricultural watersheds with medium to high erosion potential in the surveyed area of southwestern Ontario.

Weather conditions for the two survey years are summarized in Tables 1 and 2. Temperatures were near normal for both years. The first year of the survey (1988) was generally dry throughout the survey area, especially in April, May, and June. The second year (1989) was wetter, especially in the extreme south of the region, where flooding often delayed seeding, or necessitated a second seeding operation.

Table 1. Monthly mean temperature for one selected weather station in each of the surveyed counties.

County	Station	April	May	June	July
		Mean temperature (C) and deviation from normal[1]			
(a) 1988					
Essex	Harrow	8.1 (0.2)	16.0 (1.8)	20.5 (0.8)	23.7 (1.7)
Kent	Ridgetown	8.1 (0.8)	14.6 (1.5)	19.9 (0.9)	24.2 (2.7)
Elgin	St. Thomas[2]	7.2	14.9	18.2	22.5
Lambton	Sarnia	4.9 (-2.2)	12.0 (-0.4)	18.1 (0)	21.1 (0.2)
Middlesex	Strathroy	6.6 (-0.5)	13.1 (0.7)	18.6 (0.5)	22.9 (2.0)
Oxford	Springford[2]	7.0	14.9	18.4	23.1
Brant	Brantford	6.6 (0.1)	14.8 (1.7)	18.8 (0.4)	23.2 (2.3)
Huron	Exeter	6.4 (-0.3)	14.3 (1.7)	17.5 (0.4)	22.8 (2.5)
Perth	Stratford	5.9 (0.6)	13.7 (1.9)	17.0 (0)	21.5 (2.3)
Waterloo	Preston	6.4 (0.4)	14.5 (2.4)	18.3 (0.9)	22.7 (2.7)
Wellington	Fergus	5.0 (0.2)	13.9 (2.5)	17.0 (0.3)	22.2 (3.0)
(b) 1989					
Essex	Harrow	6.8 (-1.1)	13.7 (-0.5)	19.5 (-0.2)	22.5 (0.5)
Kent	Ridgetown	6.2 (-1.1)	13.6 (0.1)	19.8 (0.8)	22.2 (0.7)
Elgin	St. Thomas[2]	5.9	13.6	18.6	21.4
Lambton	Sarnia	4.9 (-2.2)	12.0 (-0.4)	18.1 (0)	21.1 (0.2)
Middlesex	Strathroy	5.7 (-1.4)	13.2 (0.1)	19.1 (0.6)	21.7 (0.8)
Oxford	Springford[2]	5.4	13.4	18.7	21.5
Brant	Brantford	5.3 (-1.2)	13.3 (0.2)	18.6 (0.2)	21.6 (0.7)
Huron	Exeter	4.9 (-1.8)	12.7 (0.1)	18.4 (0.5)	21.4 (1.1)
Perth	Stratford	3.9 (-1.4)	12.2 (0.4)	17.8 (0.8)	20.2 (1.0)
Waterloo	Preston	5.1 (-0.9)	13.0 (0.9)	18.3 (0.9)	21.3 (1.3)
Wellington	Fergus	3.8 (-1.0)	12.1 (0.7)	17.8 (1.1)	21.1 (1.9)

[1]Data from Monthly Record Meteorological Observations in Canada, Atmospheric Environment Service, Environment Canada

[2]Normals unavailable

Table 2. Total monthly precipitation for one selected weather station in each of the surveyed counties.

		Total precipitation (mm) and % of normal[1]			
County	Station	April	May	June	July
(a) 1988					
Essex	Harrow	48 (60)	14 (20)	23 (31)	110 (139)
Kent	Ridgetown	46 (54)	47 (70)	15 (9)	66 (91)
Elgin	St. Thomas[2]	58	45	13	92
Lambton	Sarnia	60 (66)	23 (34)	21 (31)	106 (174)
Middlesex	Strathroy	61 (75)	87 (138)	14 (17)	124 (173)
Oxford	Springford[2]	85	49	12	175
Brant	Brantford	56 (73)	55 (83)	6 (8)	197 (271)
Huron	Exeter	53 (64)	54 (76)	15 (20)	67 (81)
Perth	Stratford	71 (87)	60 (82)	12 (14)	110 (146)
Waterloo	Preston	65 (81)	52 (70)	11 (12)	153 (203)
Wellington	Fergus	77 (97)	34 (44)	16 (18)	111 (148)
(b) 1989					
Essex	Harrow	77 (95)	166 (229)	133 (176)	302 (382)
Kent	Ridgetown	47 (55)	133 (197)	89 (115)	35 (48)
Elgin	St. Thomas[2]	78	105	107	62
Lambton	Sarnia	51 (56)	88 (131)	81 (121)	59 (98)
Middlesex	Strathroy	80 (99)	95 (151)	58 (69)	39 (54)
Oxford	Springford[2]	70	77	85	42
Brant	Brantford	48 (63)	85 (127)	67 (93)	59 (81)
Huron	Exeter	47 (57)	103 (145)	55 (76)	13 (16)
Perth	Stratford	66 (81)	103 (141)	65 (80)	33 (43)
Waterloo	Preston	58 (72)	98 (132)	90 (105)	18 (24)
Wellington	Fergus	64 (81)	117 (149)	106 (123)	10 (14)

[1]Data from Monthly Record Meteorological Observations in Canada, Atmospheric Environment Service, Environment Canada

[2]Normals unavailable

II. FIELD SURVEY

Sampling Procedure

(a) Field selection

The 1988 survey covered seven counties: Essex, Kent, Lambton, Elgin, Middlesex, Huron, and Perth (Figure 3). An additional four counties were added in 1989: Waterloo, Wellington, Oxford and Brant. Haldimand and Norfolk counties were considered for the 1989 survey season, but severe flooding in the spring and early summer meant that few fields could be located in the appropriate crop and tillage combinations.

The names of farm operators involved in some form of reduced tillage were obtained from soil and crops advisors with the Ontario Ministry of Agriculture and Food (OMAF), OMAF conservation advisors, Conservation Authority agronomists, and from other farmers. Farmers were contacted by telephone, and permission to survey fields was requested. An attempt was made to locate fields in each combination of county, crop (corn, soybeans and winter wheat), tillage (conventional, conservation, or no-till) and tillage duration (first year, transitional and established). The number of farm operators surveyed in each county for 1988 and 1989 is given in Table 3. In each year, a target of 25 fields per county was sought.

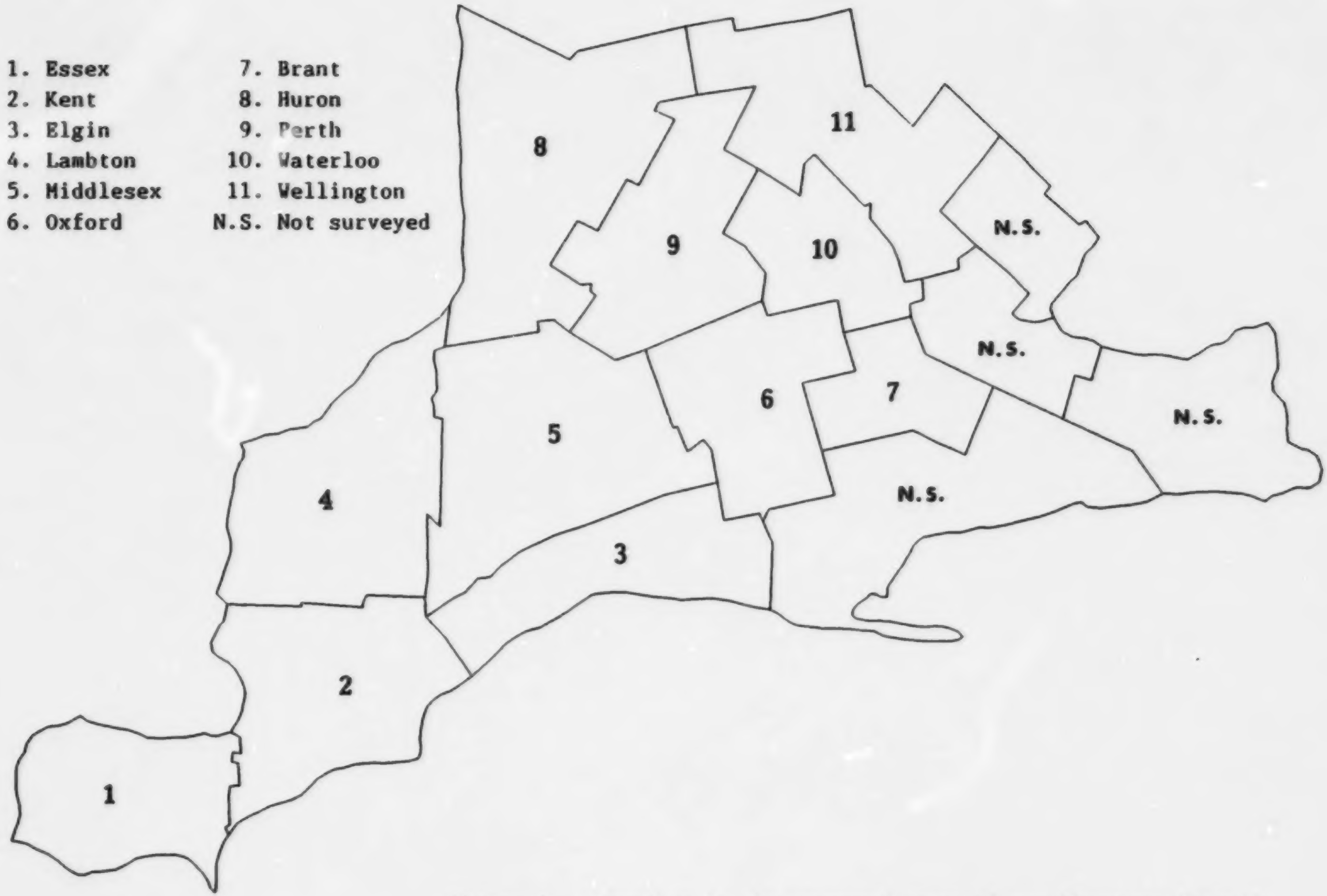

Figure 3. Counties in the surveyed area of southwestern Ontario.

Table 3. Number of farm operators included in the survey during 1988 and 1989.

County	1988	1989
Essex	11	7
Kent	9	7
Elgin	8	11
Lambton	6	14
Middlesex	8	12
Oxford	0	7
Brant	0	6
Perth	9	9
Huron	8	12
Waterloo	0	7
Wellington	0	8
TOTAL	59	100

(b) Weed counts in fields

Orientation for all survey workers included a day surveying fields with the project leader, and identifying common weeds. Weeds that were not recognized during the survey were pressed for later identification, when possible.

The survey was conducted from 27 July to 23 September 1988, and from 11 July to 28 August 1989. This time frame was chosen for several reasons. The field weed flora was, in part, a result of agronomic management decisions made by the farmer at various times during the crop year (time and type of tillage or type, rate, and effectiveness of herbicides used, etc.). By surveying in late summer, only those weeds which had escaped from cultural and chemical control and from the pressures of crop competition were counted. These surviving weeds may have contributed to a yield loss and will produce seeds to infest subsequent crops. Counts at this time of the year indicated the size and extent of troublesome weed populations. A survey at this time of the year had additional advantages. Identification was simplified because most of the weeds were mature. In particular, the grassy weeds were in flower or in fruit and easily recognized.

Once a surveyor arrived at a selected field, weed counts were obtained in 0.25 m^2 (50 cm by 50 cm) quadrats at 20 points equally spaced in the sampling pattern shown in Figure 4. The sampling pattern began 10 paces in from the edge of each headland. The surveyor selected a convenient point at which to enter the field and began the sampling procedure. Each quadrat was 10 paces from the previous. The numbers of plants of each species were counted in each quadrat and recorded on a field sheet. For perennial grasses, such as quack grass and for perennial herbaceous species such as Canada thistle, the number of shoots were counted. For annual grasses such as wild oats a rooted individual was counted as a single plant regardless of the number of tillers. If a plant could not be identified in the field, a specimen was catalogued and preserved for later identification. The sampling procedure was compressed as necessary for sampling test strips, and modified as necessary for odd shaped fields.

In addition, the presence of any species that had not been encountered in the quadrats was noted while walking through the field.

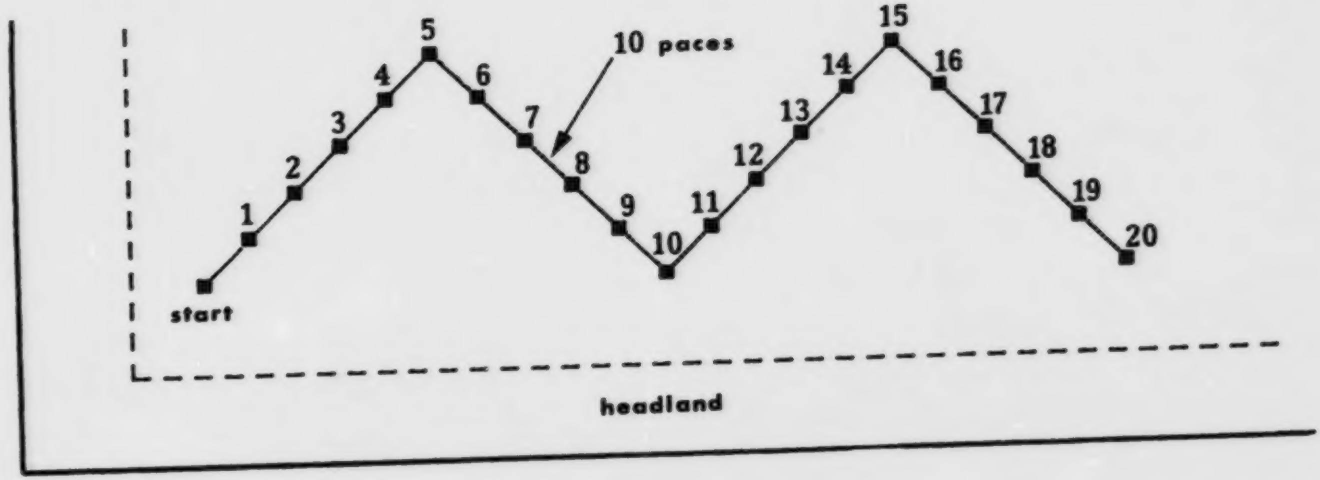

Figure 4. Sampling pattern used to survey a field.

Definition of Terms Used in the Field Survey Summaries

<u>Species</u>

This is the common name of the plants recorded during the survey. The scientific name of the species is given on pages 24-26.

<u>Frequency</u>

The number of fields in which a particular species occurred, expressed as a percentage of the total number of fields surveyed or the number of fields surveyed in a county, crop, soil series, tillage system, or other summary variable.

<u>All field uniformity</u>

The number of quadrats in which a particular species occurred, expressed as a percentage of all the quadrats surveyed (20 per field multiplied by the total number of fields), in a county, crop, soil series, tillage system, or other summary variable.

<u>Occurrence field uniformity</u>

The number of quadrats in which a particular species occurred, expressed as a percentage of the number of quadrats for the occurrence fields only (20 per field multiplied by the number of fields in which the species occurred), in a county, crop, soil series, tillage system, or other summary variable.

<u>All field density</u>

A measure of the number of plants of a species found in a field, expressed per square metre. The density values for each species in a single field are averaged over all fields surveyed in a county, crop, soil series, tillage system, or other summary variable.

<u>Occurrence field density</u>

A measure of the number of plants of each species found in a field, expressed per square metre. The density values for each species in a single field are averaged over only the fields in which the weed occurred in a county, crop, soil series, tillage system, or other summary variable.

<u>Density range</u>

The lowest and highest field density values recorded for a species in a county, crop, soil series, tillage system, or other summary variable.

<u>Relative abundance</u>

A combination of the frequency, field uniformity (all fields), and mean field density (all fields) values for each species.

Relative frequency for a species (RF)=

$$\frac{\text{frequency value of species}}{\text{sum of frequency values for all species}} \times 100$$

Relative field uniformity (all fields) for a species (RU)=

$$\frac{\text{field uniformity value of species}}{\text{sum of field uniformity value for all species}} \times 100$$

Relative mean field density (all fields) for a species (RD)=

$$\frac{\text{mean field density value of species}}{\text{sum of mean field density values for all species}} \times 100$$

Relative abundance for a species = RF + RU + RD

The total of the relative abundance values for all species equals 300. This measure was used to rank the species in the field survey summary tables. This calculation assumed that the frequency, field uniformity, and field density measures were of equal importance in estimating the abundance of a species.

This measurement has no units attached to it but the value for one species when compared to the value of another species indicates the relative abundance of each species. For example, if green foxtail has a value of 36 and redroot pigweed 18, the conclusion would be that green foxtail is twice as abundant as redroot pigweed. Relative abundance does not necessarily relate to the competitive ability of the species. A species may have a high relative abundance value but may not be very competitive.

Data analysis

(a) Field survey summary tables

A total of 593 fields were surveyed: 228 in 1988 and 365 in 1989 (Table 4). Weed count data on the field sheets were numerically coded, entered into the computer and verified. The data were processed using several procedures of the SAS® Software System (SAS Institute Inc., Cary, NC). Summaries for the 2 years were remarkably similar, despite the differences in growing conditions in those years. The data were combined for analysis. The data obtained from the quadrats were summarized in one detailed table for all 593 fields following the standard format used in reports of the Weed Survey Series (definition of terms used on page 13).

Weed data were summarized over a number of variables that were suspected of being important determinants of weed distribution. As the purpose of this survey was to document differences in weed communities associated primarily with tillage systems and secondarily with other management practices, weed data were presented first in tables summarized by tillage system (Table 5). For the purposes of the survey, tillage practices were grouped into three types: conventional (including some form of soil inversion, such as by a moldboard plow), conservation (including some soil disturbance other than inversion) and no-till (no tillage between the current and previous crop). Fields were also grouped according to the length of time that they had been managed with a given tillage type. First year fields were considered separately. Fields in the second or third year of a tillage type were considered transitional. Those in the fourth or later year were classed as established. These groupings were determined in part by available sample size. The number of fields in each category are indicated in Table 6.

The effects of cropping practices on the weed community were examined by summarizing weed data on the basis of current crop, previous crop, and rotation. These data summaries are presented separately for each tillage type. Three crops were selected for the survey: corn, soybean, winter wheat. Fields in other crops were not surveyed. An even distribution of tillage types was sought among crops. This was not possible in winter wheat. Few farmers used inversion tillage techniques prior to planting of winter wheat. The number of fields surveyed in each crop are indicated in Table 7.

Table 4. Number of fields surveyed in each county during 1988 and 1989.

County	1988	1989
Essex	29	27
Kent	32	30
Elgin	32	36
Lambton	34	36
Middlesex	35	36
Oxford	0	35
Brant	0	29
Huron	32	41
Perth	34	34
Waterloo	0	30
Wellington	0	31
TOTAL	228	365

Table 5. Number of fields surveyed for each tillage system by county

County	Tillage system			TOTAL
	Conventional	Conservation	No-till	
Essex	16	20	20	56
Kent	4	50	8	62
Elgin	17	27	24	68
Lambton	18	24	28	70
Middlesex	22	15	34	71
Oxford	9	19	7	35
Brant	2	15	12	29
Huron	24	22	27	73
Perth	27	21	20	68
Waterloo	11	11	8	30
Wellington	13	11	7	31
TOTAL	163	235	195	593

Table 6. Number of fields surveyed in each tillage system by the length of time in a tillage system.

	Category (Years)			
Tillage system	New (1)	Transitional (2 or 3)	Established (4 or more)	TOTAL
Conventional	40	22	101	163
Conservation	85	60	90	235
No-till	97	54	42	193
TOTAL	222	136	233	591

Table 7. Number of fields surveyed for each tillage system by crop.

	Surveyed crop			
Tillage system	Corn	Soybeans	Winter wheat	TOTAL
Conventional	75	70	18	163
Conservation	97	80	58	235
No-till	75	73	47	195
TOTAL	247	223	123	593

Four categories were considered for the crop previous to that surveyed: corn, bean (soybean, white bean, etc.), cereal (winter wheat, barley, oats, etc.), and perennial crops. The numbers of fields surveyed in each previous crop category are indicated in Table 8.

Table 8. Number of fields surveyed in each tillage system by the crop grown previously in the field.

	Previous crop				
Tillage system	Corn	Bean[1]	Cereal[2]	Perennial[3]	TOTAL
Conventional	90	29	31	13	163
Conservation	89	92	43	6	230
No-till	80	79	24	10	193
TOTAL	259	200	98	29	586

[1]Bean = soybean, white bean, etc.

[2]Cereal = winter wheat, barley, oats, etc.

[3]Perennial = alfalfa, clover spp., etc.

A great diversity of rotational sequences was used. Three distinct crop rotation types were identified: continuous corn, mixed annual, and perennial. Corn was the only single species used in continuous rotation in a fairly large number of fields. No other single rotation type was sufficiently unique, or occurred in sufficient number to separate as a distinct group. A mixed annual rotation included two to several species of annual or winter-annual crops but no perennial crops. A perennial rotation included a perennial crop such as alfalfa. The inclusion of perennial species in the crop rotation may have consequences to the weed community. The type of perennial crop was considered less important. The number of fields surveyed in each crop rotation are indicated in Table 9.

Table 9. Number of fields surveyed in each tillage system by crop rotation.

	Crop rotation			
Tillage system	Continuous corn	Mixed[1]	Perennial[2]	TOTAL
Conventional	9	120	30	159
Conservation	13	188	15	216
No-till	10	155	20	185
TOTAL	32	463	65	560

[1]A mixed rotation included more than one crop species but none were perennial.

[2]A perennial rotation included a perennial crop such as alfalfa.

Weed data were also summarized over geographic variables. Counties were used as convenient units of summarization to show the distribution of species in the region.

The soil family, texture, and great group associated with each field were determined from the Ontario Soil Survey Map (Report #30, Soil Association of Southern Ontario). Soil great group names were revised to reflect modern usage, based on advice from H. Rostad, Saskatchewan Soil Survey. The locations of the major soil textural groups in the surveyed area is shown in Figure 5. The number of fields surveyed in each soil family category are summarized below.

Table 10. Number of fields for each soil family, texture, and great group included in the survey.

Family	Texture	Great Group	Number of fields
(1) Very fine			
Haldimand	Clay	Grey Brown Luvisol	53
Lincoln	Clay	Humic Gleysol	51
(2) Fine			
Perth	Clay loam	Grey Brown Luvisol	129
Huron	Clay loam	Grey Brown Luvisol	57
Brookston	Clay loam	Humic Gleysol	82
Renfrew	Clay loam	Grey Luvisol	1
(3) Moderately fine			
Tuscola	Silt loam	Grey Brown Luvisol	29
Colwood	Silt loam	Humic Gleysol	4
Honeywood	Very fine sandy loam	Grey Brown Luvisol	18
(4) Medium			
London	Loam	Grey Brown Luvisol	26
Guelph	Loam	Grey Brown Luvisol	61
Dumfries	Loam	Grey Brown Luvisol	1
(5) Coarse			
Brady	Sandy loam	Grey Brown Luvisol	21
Fox	Sandy loam	Grey Brown Luvisol	47
Berrien	Sandy loam	Grey Brown Luvisol	13

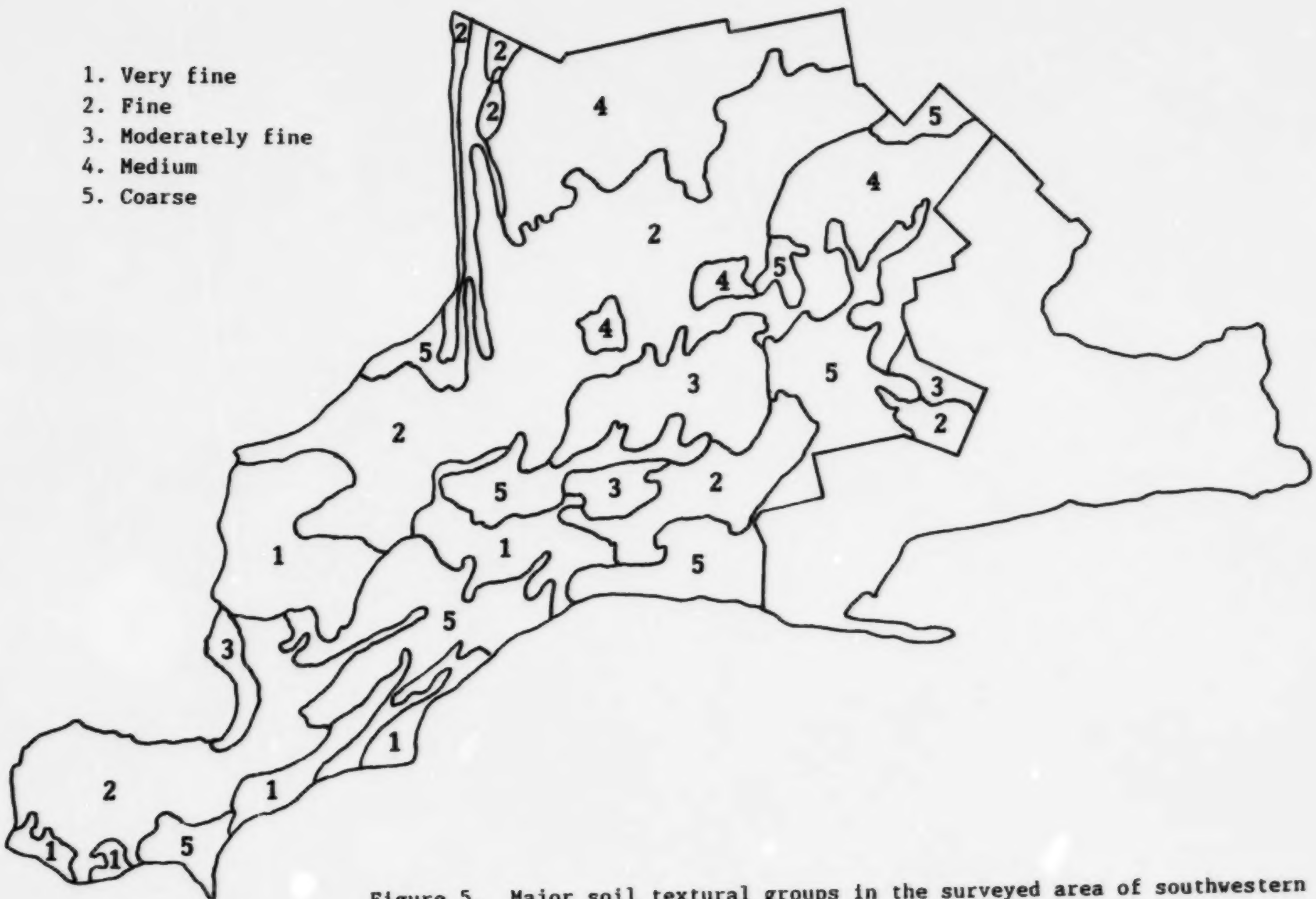

Figure 5. Major soil textural groups in the surveyed area of southwestern Ontario.

(b) Interpretative tables and maps

Detailed information from the field survey is presented in the summary table portion of the report (Tables A1-A69 of the Appendix). Various features and species were selected from these tables and organized for presentation in interpretative tables. The 19 species with the greatest frequency over the entire survey were grouped into annual broad-leaved weeds, annual grass weeds, and perennial weeds for some of the tables. All other species were included in the minor species group. In tables presenting frequency data the relative frequency for each group was calculated. Relative frequency is used to compare the contribution of each group in the three crops, in the three tillage systems, and in the number of years under a tillage system. Density data are not presented for individual species but only for each of the groups.

The geographic distribution of the species found in the survey, regardless of the tillage system, is indicated by maps based on counties. The 19 species chosen for the interpretatative tables were mapped as well as six other species that were of interest in reduced tillage systems. The variable frequency was chosen for mapping.

Common And Scientific Name Of Plants Which Appear In This Report

Common Name[1]	Scientific Name
alfalfa	*Medicago sativa* L.
annual smartweed spp.	*Polygonum lapathifolium* L., *P. scabrum* Moench and *P. persicaria* L.
annual sow-thistle	*Sonchus oleraceus* L.
barnyard grass	*Echinochloa crusgalli* (L.) Beauv.
black medick	*Medicago lupulina* L.
bladder campion	*Silene vulgaris* (Moench) Garcke
bouncingbet	*Saponaria officinalis* L.
bristly foxtail	*Setaria verticillata* (L.) Beauv.
broad-leaved plantain	*Plantago major* L.
Canada fleabane	*Erigeron canadensis* L.
Canada thistle	*Cirsium arvense* (L.) Scop.
chickweed	*Stellaria media* (L.) Vill.
clammy ground-cherry	*Physalis heterophylla* Nees
clover spp.	*Trifolium* spp.
cocklebur	*Xanthium strumarium* L.
common burdock	*Arctium minus* (Hill) Bernh.
common mallow	*Malva neglecta* Wallr.
common milkweed	*Asclepias syriaca* L.
common mullein	*Verbascum thapsus* L.
common ragweed	*Ambrosia artemisiifoila* L.
common pepper-grass	*Lepidium densiflorum* Schrad.
common yellow wood-sorrel	*Oxalis dillenii* Jacq.
crab grasses	*Digitaria* spp.
curled dock	*Rumex crispus* L.
dandelion	*Taraxacum officinale* Weber
eastern black nightshade[2]	*Solanum ptycanthum* Dun.
fall panicum	*Panicum dichotomiflorum* Michx.
field bindweed	*Convolvulus arvensis* L.

Continued on next page

Common Name[1]	Scientific Name
field horsetail	Equisetum arvense L.
field violet	Viola arvensis Murr.
flower-of-an-hour	Hibiscus trionum L.
giant foxtail	Setaria faberii Herrm.
giant ragweed	Ambrosia trifida L.
goat's-beard	Tragopogon dubius Scop.
goldenrods	Solidago spp.
green foxtail	Setaria viridis (L.) Beauv.
green pigweed	Amaranthus powellii S. Wats.
ground-ivy	Glechoma hederacea L.
hemp-nettle	Galeopsis tetrahit L.
jimsonweed	Datura stramonium L.
lamb's-quarters	Chenopodium album L.
leafy spurge	Euphorbia esula L.
mouse-eared chickweed	Cerastium fontanum Baumg. (= C. vulgatum L.)
narrow-leaved plantain	Plantago lanceolata L.
night-flowering catchfly	Silene noctiflora L.
ox-eye daisy	Chrysanthemum leucanthemum L.
perennial sow-thistle	Sonchus arvensis L.
pineappleweed	Matricaria matricarioides (Less.) Porter
prickly lettuce	Lactuca scariola L.
prostrate knotweed	Polygonum aviculare L.
purslane	Portulaca oleracea L.
purslane speedwell	Veronica peregrina L.
quack grass	Agropyron repens (L.) Beauv.
redroot pigweed	Amaranthus retroflexus L.
shepherd's-purse	Capsella bursa-pastoris (L.) Medic.
smooth ground-cherry	Physalis virginiana Mill.
smooth bedstraw	Galium mollugo L.
spotted spurge	Euphorbia nutans Lag.
spreading dogbane	Apocynum androsaemifolium L.

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Common Name[1]	Scientific Name
stinkweed	Thlaspi arvense L.
sugar maple	Acer saccharum Marsh.
timothy	Phleum pratense L.
tumble pigweed	Amaranthus albus L.
velvetleaf	Abutilon theophrasti Medic.
vetch spp.	Vicia spp.
volunteer barley	Hordeum vulgare L.
volunteer corn	Zea mays L.
volunteer winter wheat	Triticum aestivum L.
volunteer soybean	Glycine max (L.) Merr.
volunteer tomato	Lycopersicon esculentum Mill.
white cockle	Silene alba (Mill.) E.H.L. Krause
wild carrot	Daucus carota L.
wild cucumber	Echinocystis lobata (Michx.) T. & G.
wild mustard	Sinapis arvensis L.
wild buckwheat	Polygonum convolvulus L.
wild oats	Avena fatua L.
witch grass	Panicum capillare L.
wormseed mustard	Erysimum cheiranthoides L.
yarrow	Achillea millefolium L.
yellow foxtail	Setaria glauca (L.) Beauv.
yellow nut sedge	Cyperus esculentus L.

[1]Common names used in this report are those listed in the publication "Common and Botanical Names of Weeds in Canada" by J.F. Alex, R. Cayouette and G.A. Mulligan (Agric. Canada Publ. 1397)

[2] The common name for "eastern black nightshade" has been shortened to "black nightshade" throughout the remainder of this report.

Limitations of field survey information

The survey results indicated the size of the weed populations that remained in the fields in late summer. These populations were composed of individuals with a wide spectrum of biomass, vigour, and reproductive potential. Although this variation was recognized, it was not recorded in the survey. Only the number of individuals, regardless of their relative impact on crop performance, was used in the analyses. The analyses presented here treated each species independently of all other species in the field; however, there was an average of 5.3 species per field. The association, or lack of association in some cases, of specific species is an important aspect of the data that remains to be explored.

Fields were selected within each county to represent the three tillage types and three current crops. An attempt was made to include fields that had been in reduced tillage for various lengths of time. These criteria were established to increase the chances that differences in the weed communities in different tillage systems could be detected. This primary interest in tillage types may have resulted in bias in other data summaries. The technique did not give numbers of surveyed fields of a given type that corresponded to the proportion of that type within the study area. For instance, the number of winter wheat fields surveyed nearly equalled the number of corn fields surveyed, even though corn was a more common crop in the surveyed areas. Field types that were difficult to find, for example, winter wheat planted on plowed land, may be over-represented.

Fields were located through farmers known for their adoption of reduced tillage methods. Difficulties in locating cooperators, necessitated this technique. This method may over-represent the farm management techniques of farmers with several different fields. Reduced tillage was a farm practice that was often introduced experimentally on small fields, or in strips within larger fields. Although headlands and field margins were avoided where possible, weed data collected in small fields may show a greater influence of adjacent areas than would data gathered from larger fields. At the other extreme, some fields were very large. The survey covered approximately 0.5 ha per field, and may therefore not represent the weed communities of the entire field.

Several species are recorded infrequently in the survey. These may be rare throughout the fields, or they may be abundant in areas of fields that

were intentionally excluded, such as headlands, creeks and ponds. Differences in the weed communities of field margins relative to those of central areas of fields may be more pronounced in reduced tillage. Standing stubble can act to trap wind-dispersed weed seeds in headlands as they blow in from adjacent areas. This is especially likely with dandelion, which is perceived by no-till producers as a greater weed problem than the survey indicates.

The survey was conducted over a two month period in both years. Weed counts may have changed somewhat over that period. For corn and soybeans, the canopy was closed throughout the survey period. This would limit new weed emergence over that time period. An attempt was made to visit winter wheat fields prior to harvest, or at least before seedlings began to emerge in the stubble. This was not always possible.

Some species presented identification problems. Species that could not be separated reliably in the field have been grouped together.

Interpretative tables

Table 11. Frequencies (%) of species and relative frequencies of weed groups in fields managed with various tillage systems

	Tillage system		
Weed group and species	Conventional	Conservation	No-till
Annual broad-leaved			
lamb's-quarters	53	55	47
redroot pigweed	33	40	49
common ragweed	37	30	38
annual smartweeds	20	22	23
velvetleaf	12	20	18
wild buckwheat	14	20	21
common yellow wood-sorrel	10	9	15
black nightshade	4	13	7
prostrate knotweed	3	8	12
Relative frequency of group	38	42	40
Annual grass			
green foxtail	44	51	47
crab grasses	7	12	12
barnyard grass	18	16	14
witch grass	11	11	14
Relative frequency of group	16	17	15
Perennial			
quack grass	51	36	41
dandelion	22	26	39
field bindweed	22	13	21
common milkweed	23	18	24
yellow nut sedge	6	9	11
broad-leaved plantain	4	11	12
Relative frequency of group	26	22	26
Minor species			
Relative frequency of group	20	19	19

Table 12. The total density (no./m^2) of weed groups in fields managed with various tillage systems

	Tillage system		
Weed group	Conventional	Conservation	No-till
Annual broad-leaved	4.7	9.4	9.9
Annual grass	4.5	8.2	8.3
Perennial	5.1	3.9	7.4
Minor species	2.7	3.1	6.1
TOTAL	17.0	24.7	31.7

Table 13. Frequencies (%) of species and relative frequencies of weed groups in fields managed for 1, 2 or 3, and 4 or more years with a conservation tillage system compared to fields managed for 4 or more years with a conventional tillage system

Weed group and species	Conventional tillage system (4 or more years)	Years with a conservation system		
		1	2 or 3	4 or more
Annual broad-leaved				
lamb's-quarters	53	52	52	59
redroot pigweed	27	41	28	46
common ragweed	43	37	22	30
annual smartweeds	22	22	18	23
velvetleaf	15	14	13	30
wild buckwheat	16	17	20	23
common yellow wood-sorrel	10	8	10	10
black nightshade	5	11	8	19
prostrate knotweed	6	11	5	8
Relative frequency of group	40	36	39	49
Annual grass				
green foxtail	45	58	45	48
crab grasses	6	17	13	8
barnyard grass	21	20	17	11
witch grass	9	12	10	10
Relative frequency of group	17	18	19	15
Perennial				
quack grass	49	47	33	28
dandelion	16	40	17	19
field bindweed	26	13	8	17
common milkweed	30	17	17	20
yellow nut sedge	6	17	7	4
broad-leaved plantain	4	17	5	10
Relative frequency of group	27	26	19	19
Minor species				
Relative frequency of group	16	20	23	17

Table 14. Frequencies (%) of species and relative frequencies of weed groups in fields managed for 1, 2 or 3, and 4 or more years with a no-till system compared to fields managed for 4 or more years with a conventional tillage system

Weed group and species	Conventional tillage system (4 or more years)	Years with a no-till system		
		1	2 or 3	4 or more
Annual broad-leaved				
lamb's-quarters	53	54	37	45
redroot pigweed	27	49	52	45
common ragweed	43	47	24	36
annual smartweeds	22	30	6	29
velvetleaf	15	18	7	33
wild buckwheat	16	27	20	7
common yellow wood-sorrel	10	17	15	12
black nightshade	5	4	7	14
prostrate knotweed	6	18	2	12
Relative frequency of group	40	42	35	38
Annual grass				
green foxtail	45	55	35	45
crab grasses	6	12	7	19
barnyard grass	21	10	9	31
witch grass	9	17	11	14
Relative frequency of group	16	15	13	18
Perennial				
quack grass	49	45	41	31
dandelion	16	41	37	38
field bindweed	26	19	17	31
common milkweed	30	18	30	31
yellow nut sedge	6	7	15	12
broad-leaved plantain	4	11	7	19
Relative frequency of group	27	23	30	27
Minor species				
Relative frequency of group	16	20	22	17

Table 15. The total density (no./m^2) of weed groups in fields managed for 1, 2 or 3, and 4 or more years with various tillage systems

	Years		
Tillage system and weed group	1	2 or 3	4 or more
Conventional			
Annual broad-leaved	4.0	8.3	4.1
Annual grass	2.3	9.7	4.3
Perennial	3.4	6.1	5.5
Minor species	2.5	6.1	2.1
TOTAL	12.2	30.2	16.0
Conservation			
Annual broad-leaved	10.1	13.4	6.2
Annual grass	15.9	5.9	2.4
Perennial	6.7	3.2	1.9
Minor species	3.7	3.5	2.4
TOTAL	36.4	25.9	12.9
No-till			
Annual broad-leaved	11.2	8.4	9.3
Annual grass	7.2	9.9	9.2
Perennial	9.6	5.6	4.9
Minor species	3.9	3.8	14.4
TOTAL	31.9	27.8	37.8

Table 16. Frequencies (%) of species and relative frequencies of weed groups in different crops.

Weed group and species	Crop		
	Corn	Soybean	Winter wheat
Annual broad-leaved			
lamb's-quarters	52	51	53
redroot pigweed	47	41	28
common ragweed	19	40	57
annual smartweeds	14	17	45
velvetleaf	21	19	6
wild buckwheat	10	14	43
common yellow wood-sorrel	10	6	23
black nightshade	8	11	7
prostrate knotweed	4	7	18
Relative frequency of group	36	42	47
Annual grass			
green foxtail	52	44	48
crab grasses	14	8	10
barnyard grass	17	18	10
witch grass	15	8	12
Relative frequency of group	19	16	12
Perennial			
quack grass	45	32	53
dandelion	31	23	35
field bindweed	18	17	21
common milkweed	23	19	21
yellow nut sedge	11	7	8
broad-leaved plantain	7	5	23
Relative frequency of group	26	21	25
Minor species			
Relative frequency of group	19	21	22

Table 17. The total density (no./m^2) of weed groups in the three surveyed crops

	Crop		
Weed group	Corn	Soybean	Winter wheat
Annual broad-leaved	7.5	6.2	13.5
Annual grass	7.5	3.7	13.0
Perennial	4.8	4.0	9.1
Minor species	5.6	2.1	4.2
TOTAL	25.4	16.0	39.9

Table 18. Frequencies (%) of species and relative frequencies of weed groups in corn fields managed with various tillage systems

	Tillage system		
Weed group and species	Conventional	Conservation	No-till
Annual broad-leaved			
lamb's-quarters	55	58	43
redroot pigweed	36	49	55
common ragweed	17	17	24
annual smartweeds	15	12	15
velvetleaf	12	28	21
wild buckwheat	7	9	15
common yellow wood-sorrel	13	6	12
black nightshade	3	16	4
prostrate knotweed	3	2	8
Relative frequency of group	33	39	36
Annual grass			
green foxtail	51	54	51
crab grasses	9	21	11
barnyard grass	20	17	15
witch grass	17	10	20
Relative frequency of group	20	20	18
Perennial			
quack grass	55	37	44
dandelion	24	27	43
field bindweed	24	8	24
common milkweed	25	20	25
yellow nut sedge	5	13	12
broad-leaved plantain	1	9	9
Relative frequency of group	28	23	29
Minor species			
Relative frequency of group	19	18	17

Table 19. Frequencies (%) of species and relative frequencies of weed groups in soybean fields managed with various tillage systems

	Tillage system		
Weed group and species	Conventional	Conservation	No-till
Annual broad-leaved			
lamb's-quarters	53	54	45
redroot pigweed	34	40	49
common ragweed	53	28	40
annual smartweeds	17	14	21
velvetleaf	14	21	22
wild buckwheat	17	15	11
common yellow wood-sorrel	4	4	11
black nightshade	7	15	10
prostrate knotweed	3	4	15
Relative frequency of group	43	43	41
Annual grass			
green foxtail	41	43	47
crab grasses	4	5	15
barnyard grass	16	20	18
witch grass	4	10	10
Relative frequency of group	14	17	16
Perennial			
quack grass	44	31	22
dandelion	17	19	34
field bindweed	20	10	21
common milkweed	19	19	19
yellow nut sedge	7	6	8
broad-leaved plantain	6	0	10
Relative frequency of group	24	19	21
Minor species			
Relative frequency of group	19	21	22

Table 20. Frequencies (%) of species and relative frequencies of weed groups in winter wheat fields managed with various tillage systems

	Tillage system		
Weed group and species	Conventional	Conservation	No-till
Annual broad-leaved			
lamb's-quarters	50	50	57
redroot pigweed	11	24	38
common ragweed	56	57	57
annual smartweeds	50	48	38
velvetleaf	6	5	6
wild buckwheat	33	45	45
common yellow wood-sorrel	17	22	26
black nightshade	0	7	9
prostrate knotweed	11	24	13
Relative frequency of group	41	43	43
Annual grass			
green foxtail	28	57	43
crab grasses	11	9	11
barnyard grass	17	9	9
witch grass	11	12	13
Relative frequency of group	12	13	11
Perennial			
quack grass	61	41	64
dandelion	22	35	40
field bindweed	22	26	15
common milkweed	22	14	30
yellow nut sedge	0	7	13
broad-leaved plantain	11	29	19
Relative frequency of group	24	23	27
Minor species			
Relative frequency of group	23	21	19

Table 21. The total density (no./m^2) of weed groups in the surveyed crop fields managed with various tillage systems

	Tillage system		
Crop and weed group	Conventional	Conservation	No-till
Corn			
Annual broad-leaved	4.4	10.7	6.6
Annual grass	5.7	9.3	7.0
Perennial	5.3	4.3	5.3
Minor species	2.3	4.8	9.7
TOTAL	17.4	29.1	28.6
Soybean			
Annual broad-leaved	4.7	3.5	10.5
Annual grass	2.6	2.9	5.5
Perennial	3.0	2.5	6.6
Minor species	2.4	1.0	3.0
TOTAL	12.7	10.0	25.6
Winter wheat			
Annual broad-leaved	5.6	15.5	14.2
Annual grass	7.2	13.5	14.7
Perennial	13.2	5.4	12.1
Minor species	5.7	3.1	5.1
TOTAL	31.7	37.5	46.1

Table 22. Frequencies (%) of species and relative frequencies of weed groups in fields managed with various tillage systems when corn is the previous crop

	Tillage system		
Weed group and species	Conventional	Conservation	No-till
Annual broad-leaved			
lamb's-quarters	50	57	49
redroot pigweed	29	40	51
common ragweed	36	20	34
annual smartweeds	14	17	15
velvetleaf	12	21	20
wild buckwheat	16	10	14
common yellow wood-sorrel	16	10	15
black nightshade	4	14	6
prostrate knotweed	3	7	14
Relative frequency of group	37	41	35
Annual grass			
green foxtail	48	49	59
crab grasses	8	15	18
barnyard grass	19	12	18
witch grass	12	11	20
Relative frequency of group	18	18	19
Perennial			
quack grass	47	27	30
dandelion	22	25	40
field bindweed	28	8	23
common milkweed	24	14	25
yellow nut sedge	6	11	11
broad-leaved plantain	7	9	11
Relative frequency of group	27	19	23
Minor species			
Relative frequency of group	18	22	23

Table 23. Frequencies (%) of species and relative frequencies of weed groups in fields managed with various tillage systems when bean is the previous crop

	Tillage system		
Weed group and species	Conventional	Conservation	No-till
Annual broad-leaved			
lamb's-quarters	55	51	49
redroot pigweed	55	36	47
common ragweed	41	42	51
annual smartweeds	24	26	30
velvetleaf	21	22	15
wild buckwheat	10	24	28
common yellow wood-sorrel	0	11	10
black nightshade	7	14	6
prostrate knotweed	7	9	10
Relative frequency of group	50	45	45
Annual grass			
green foxtail	35	51	41
crab grasses	7	7	5
barnyard grass	17	16	11
witch grass	7	9	5
Relative frequency of group	15	16	11
Perennial			
quack grass	41	38	43
dandelion	3	22	32
field bindweed	10	19	20
common milkweed	17	25	29
yellow nut sedge	7	5	11
broad-leaved plantain	0	12	11
Relative frequency of group	17	23	27
Minor species			
Relative frequency of group	18	16	17

Table 24. Frequencies (%) of species and relative frequencies of weed groups in fields managed with various tillage systems when cereal is the previous crop

	Tillage system		
Weed group and species	Conventional	Conservation	No-till
Annual broad-leaved			
lamb's-quarters	58	56	42
redroot pigweed	23	40	46
common ragweed	45	26	21
annual smartweeds	35	26	25
velvetleaf	10	16	25
wild buckwheat	16	33	17
common yellow wood-sorrel	3	7	25
black nightshade	0	12	17
prostrate knotweed	3	9	13
Relative frequency of group	38	41	42
Annual grass			
green foxtail	45	47	25
crab grasses	3	16	13
barnyard grass	16	19	13
witch grass	7	9	17
Relative frequency of group	14	17	12
Perennial			
quack grass	65	49	54
dandelion	29	35	50
field bindweed	23	7	21
common milkweed	26	11	13
yellow nut sedge	7	14	8
broad-leaved plantain	0	14	13
Relative frequency of group	29	24	29
Minor species			
Relative frequency of group	19	18	17

Table 25. The total density (no./m²) of weed groups in fields planted previously to different crop and managed with various tillage systems

	Tillage system		
Crop and weed group	Conventional	Conservation	No-till
Previously corn			
Annual broad-leaved	3.0	6.4	7.8
Annual grass	4.9	9.0	11.1
Perennial	5.3	4.6	4.9
Minor species	3.3	3.6	3.0
TOTAL	16.5	23.6	26.8
Previously bean			
Annual broad-leaved	9.7	13.3	11.4
Annual grass	5.1	7.1	4.5
Perennial	4.6	2.7	5.5
Minor species	2.3	2.0	3.6
TOTAL	21.7	25.2	24.9
Previously cereal			
Annual broad-leaved	4.9	6.6	15.0
Annual grass	2.2	8.4	3.9
Perennial	4.8	4.9	18.0
Minor species	2.1	1.1	23.9
TOTAL	14.0	21.0	60.7

Table 26. Frequencies (%) of species and relative frequencies of weed groups in fields managed with various tillage systems in a continuous corn rotation

	Tillage system		
Weed group and species	Conventional	Conservation	No-till
Annual broad-leaved			
lamb's-quarters	56	54	50
redroot pigweed	33	39	40
common ragweed	11	15	30
annual smartweeds	11	23	0
velvetleaf	0	15	30
wild buckwheat	22	23	10
common yellow wood-sorrel	22	0	20
black nightshade	0	0	0
prostrate knotweed	11	7	10
Relative frequency of group	28	37	26
Annual grass			
green foxtail	67	39	70
crab grasses	11	31	30
barnyard grass	33	39	20
witch grass	22	7	30
Relative frequency of group	22	25	21
Perennial			
quack grass	44	39	40
dandelion	33	31	70
field bindweed	44	0	30
common milkweed	0	7	30
yellow nut sedge	11	7	20
broad-leaved plantain	11	0	10
Relative frequency of group	24	18	27
Other remaining species			
Relative frequency of group	26	20	26

Table 27. Frequencies (%) of species and relative frequencies of weed groups in fields managed with various tillage systems in a mixed annual crop rotation

	Tillage system		
Weed group and species	Conventional	Conservation	No-till
Annual broad-leaved			
lamb's-quarters	52	54	47
redroot pigweed	31	36	49
common ragweed	42	32	42
annual smartweeds	22	22	25
velvetleaf	15	22	20
wild buckwheat	14	20	21
common yellow wood-sorrel	7	11	13
black nightshade	5	13	7
prostrate knotweed	4	7	12
Relative frequency of group	42	43	42
Annual grass			
green foxtail	38	47	45
crab grasses	6	9	11
barnyard grass	17	12	16
witch grass	8	10	10
Relative frequency of group	15	15	15
Perennial			
quack grass	48	35	38
dandelion	16	25	33
field bindweed	21	13	20
common milkweed	25	19	25
yellow nut sedge	7	10	8
broad-leaved plantain	4	11	12
Relative frequency of group	26	22	24
Minor species			
Relative frequency of group	17	20	19

Table 28. Frequencies (%) of species and relative frequencies of weed groups in fields managed with various tillage systems in a mixed annual and perennial crop rotation

	Tillage system		
Weed group and species	Conventional	Conservation	No-till
Annual broad-leaved			
lamb's-quarters	57	67	35
redroot pigweed	33	40	40
common ragweed	23	20	0
annual smartweeds	13	13	15
velvetleaf	7	7	0
wild buckwheat	13	20	25
common yellow wood-sorrel	20	0	25
black nightshade	3	7	10
prostrate knotweed	0	13	10
Relative frequency of group	33	31	26
Annual grass			
green foxtail	53	67	50
crab grasses	13	27	10
barnyard grass	13	27	0
witch grass	20	20	35
Relative frequency of group	19	23	16
Perennial			
quack grass	57	60	60
dandelion	37	47	70
field bindweed	13	0	15
common milkweed	17	20	10
yellow nut sedge	0	13	25
broad-leaved plantain	3	0	10
Relative frequency of group	24	23	31
Other remaining species			
Relative frequency of group	24	23	27

Table 29. The total density (no./m^2) of weed groups in fields managed with various crop rotations and tillage systems

Crop rotation and weed group	Tillage system		
	Conventional	Conservation	No-till
Continuous corn			
Annual broad-leaved	2.5	6.0	9.7
Annual grass	14.2	15.0	26.7
Perennial	4.9	9.3	14.0
Other remaining species	5.8	2.7	7.5
TOTAL	27.4	33.0	57.8
Mixed annual crops			
Annual broad-leaved	5.1	9.9	10.5
Annual grass	3.7	5.4	7.5
Perennial	5.3	3.5	6.1
Other remaining species	2.7	2.9	6.5
TOTAL	16.8	21.6	30.6
Mixed annual and perennial crops			
Annual broad-leaved	3.0	4.9	3.6
Annual grass	4.8	12.1	2.8
Perennial	3.2	5.8	12.7
Other remaining species	2.0	2.4	3.6
TOTAL	13.0	25.3	22.6

Table 30. The average number of species per field for each tillage system, number of years in tillage system, crop, crop grown previously, and rotation

	Tillage system			
	Conventional	Conservation	No-till	Mean
Tillage system	4.9	5.2	5.8	5.3
Years in tillage system				
1	4.1	5.8	6.2	5.7
2 or 3	6.3	4.5	4.9	5.0
4 or more	4.9	5.1	6.1	5.2
Crop				
Corn	4.5	5.0	6.6	4.9
Soybean	4.7	4.8	5.7	5.1
Winter wheat	5.5	5.5	6.7	6.5
Previous crop				
Corn	4.9	4.8	6.2	5.3
Bean	4.5	5.2	5.4	5.2
Cereal	5.2	5.5	5.5	5.4
Rotation				
Continuous corn	6.0	4.7	7.3	5.9
Mixed annual	4.6	5.1	5.6	5.1
Mixed annual and perennial	5.2	6.1	6.1	5.7

Table 31. The total density (no./m^2) of weed groups in each of the surveyed counties

County	Weed group				
	Annual broad-leaved	Annual grass	Perennial	Other	Total
Essex	13.8	4.8	1.9	10.6	31.1
Kent	7.7	7.6	1.0	6.3	22.6
Elgin	9.2	10.2	9.2	5.6	34.2
Lambton	12.0	5.4	4.6	3.4	25.4
Middlesex	6.1	4.1	7.1	0.6	17.8
Oxford	7.8	3.3	1.9	2.6	15.6
Brant	4.2	8.7	2.8	1.7	17.4
Huron	3.8	7.1	5.0	1.3	17.1
Perth	5.3	10.0	5.8	4.3	25.4
Waterloo	14.8	12.1	6.9	3.4	37.1
Wellington	9.4	8.0	15.1	3.1	35.5

Table 32. The average number of species per field in each county

County	Average
Essex	4.9
Kent	4.6
Elgin	5.7
Lambton	5.3
Middlesex	4.9
Oxford	3.9
Brant	4.7
Huron	5.2
Perth	6.6
Waterloo	6.5
Wellington	5.9

Table 33. Frequencies (%) of species and relative frequencies of weed groups in fields on very fine textured soils (clay) of the Haldimand and Lincoln soil families

Weed group and species	Haldimand	Lincoln
Annual broad-leaved		
lamb's-quarters	55	47
redroot pigweed	47	59
common ragweed	55	37
annual smartweeds	19	10
velvetleaf	11	35
wild buckwheat	6	4
common yellow wood-sorrel	6	8
black nightshade	4	28
prostrate knotweed	8	2
Relative frequency of group	40	46
Annual grass		
green foxtail	38	53
crab grasses	15	12
barnyard grass	21	26
witch grass	4	8
Relative frequency of group	15	20
Perennial		
quack grass	62	24
dandelion	25	22
field bindweed	0	8
common milkweed	25	10
yellow nut sedge	9	4
broad-leaved plantain	4	12
Relative frequency of group	24	16
Other remaining species		
Relative frequency of group	21	18

Table 34. Frequencies (%) of species and relative frequencies of weed groups in fields on fine textured soils (clay loam) of the Perth, Huron, and Brookston soil families

Weed group and species	Perth	Huron	Brookston
Annual broad-leaved			
lamb's-quarters	62	65	51
redroot pigweed	49	47	32
common ragweed	37	23	40
annual smartweeds	22	23	29
velvetleaf	16	4	51
wild buckwheat	26	25	12
common yellow wood-sorrel	9	16	5
black nightshade	5	0	13
prostrate knotweed	8	14	13
Relative frequency of group	42	34	46
Annual grass			
green foxtail	59	49	56
crab grasses	5	11	16
barnyard grass	16	14	23
witch grass	11	25	12
Relative frequency of group	16	16	20
Perennial			
quack grass	53	49	17
dandelion	31	40	23
field bindweed	28	28	20
common milkweed	19	33	7
yellow nut sedge	8	0	7
broad-leaved plantain	8	16	18
Relative frequency of group	26	26	17
Other remaining species			
Relative frequency of group	16	24	17

Table 35. Frequencies (%) of species and relative frequencies of weed groups in fields on moderately fine (silt loam, very fine sandy loam) soils of the Tuscola and Honeywood soil families and medium textured soils (loam) of the London and Guelph soil families

Weed group and species	Tuscola	Honeywood	London	Guelph
Annual broad-leaved				
lamb's-quarters	24	33	62	36
redroot pigweed	21	22	50	25
common ragweed	24	50	31	15
annual smartweeds	10	17	19	23
velvetleaf	0	17	0	0
wild buckwheat	14	17	27	30
common yellow wood-sorrel	3	17	19	15
black nightshade	0	0	8	3
prostrate knotweed	10	0	8	2
Relative frequency of group	31	40	38	33
Annual grass				
green foxtail	28	33	39	33
crab grasses	10	0	8	12
barnyard grass	3	11	19	10
witch grass	0	6	12	21
Relative frequency of group	12	12	13	17
Perennial				
quack grass	38	61	35	44
dandelion	48	17	39	26
field bindweed	3	11	46	18
common milkweed	21	33	46	38
yellow nut sedge	10	22	0	2
broad-leaved plantain	3	6	4	7
Relative frequency of group	36	35	29	30
Other remaining species				
Relative frequency of group	21	13	20	20

Table 36. Frequencies (%) of species and relative frequencies of weed groups in fields on coarse textured soils (sandy loam) of the Brady, Fox, and Berrien soil families

Weed group and species	Brady	Fox	Berrien
Annual broad-leaved			
lamb's-quarters	52	43	69
redroot pigweed	33	45	23
common ragweed	10	38	69
annual smartweeds	14	23	62
velvetleaf	29	0	15
wild buckwheat	0	21	31
common yellow wood-sorrel	0	26	31
black nightshade	24	13	8
prostrate knotweed	0	15	8
Relative frequency of group	55	34	49
Annual grass			
green foxtail	48	47	54
crab grasses	5	23	15
barnyard grass	5	11	8
witch grass	5	17	8
Relative frequency of group	21	15	13
Perennial			
quack grass	5	49	69
dandelion	5	40	15
field bindweed	5	4	31
common milkweed	5	15	15
yellow nut sedge	0	38	23
broad-leaved plantain	5	11	0
Relative frequency of group	8	24	24
Other remaining species			
Relative frequency of group	16	27	14

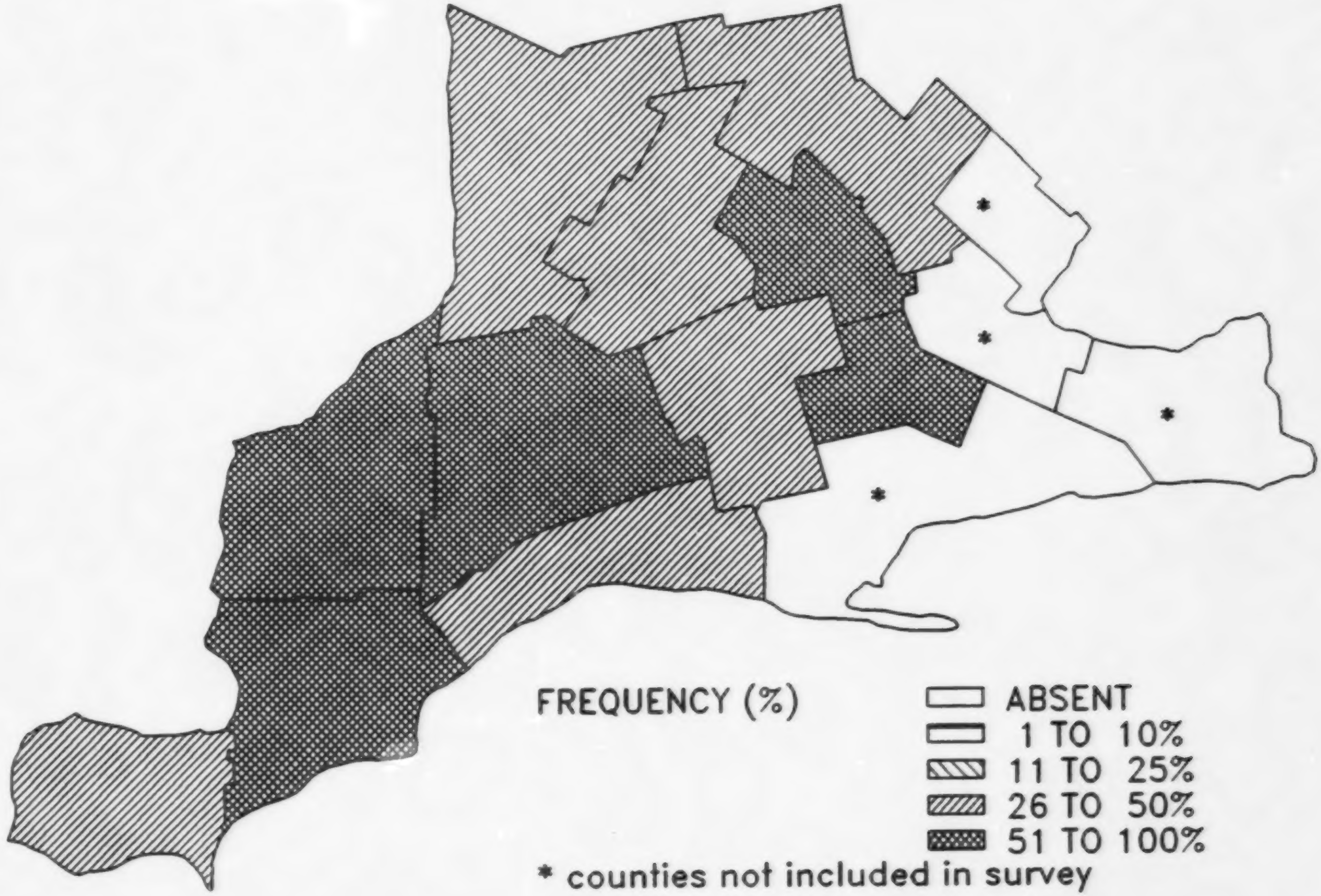
Table 37. The total density (no./m^2) of weed groups on each of the surveyed soil types

Soil type	Weed group				
	Annual broad-leaved	Annual grass	Perennial	Minor	Total
Haldimand clay	9.4	8.8	11.2	6.5	35.8
Lincoln clay	8.6	3.4	2.3	7.3	21.6
Perth clay	9.1	6.8	6.8	2.3	25.1
Huron clay loam	8.8	11.2	5.9	3.8	29.6
Brookston clay loam	11.6	8.4	1.8	8.8	30.6
Tuscola silt loam	7.5	2.2	1.8	2.2	13.8
Honeywood very fine sandy loam	2.8	1.4	2.0	0.6	6.8
London loam	8.9	3.7	3.5	2.8	19.0
Guelph loam	5.8	5.0	5.8	2.0	18.5
Brady sandy loam	4.6	0.8	0.3	0.2	6.0
Fox sandy loam	5.4	13.1	9.2	2.1	29.7
Berrien sandy loam	9.0	23.4	11.4	2.1	45.9

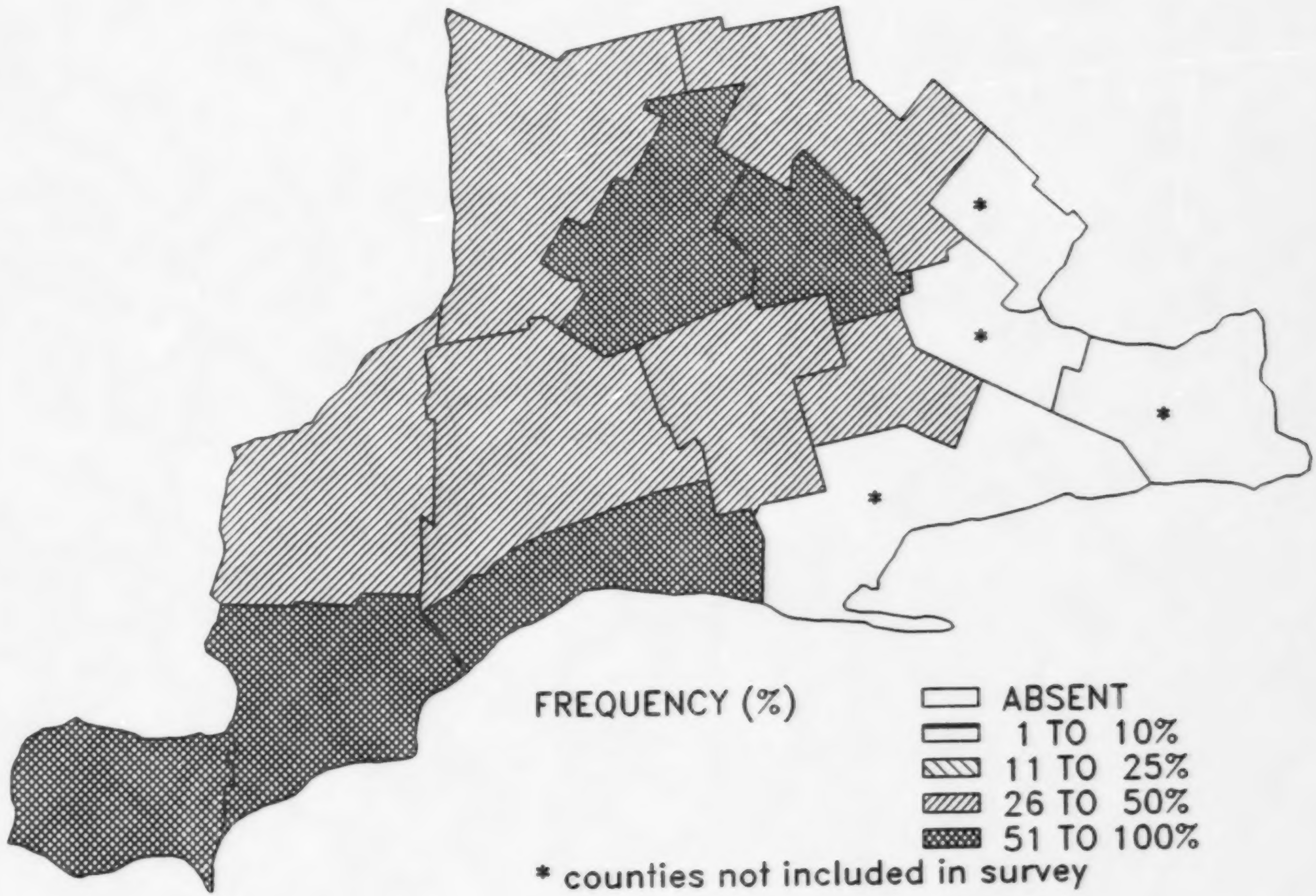
Table 38. The average number of species per field on each soil type

Soil type	Average
Haldimand clay	5.3
Lincoln clay	5.0
Perth clay	5.6
Huron clay loam	6.3
Brookston clay loam	5.4
Tuscola silt loam	3.4
Honeywood very fine sandy loam	4.3
London loam	5.9
Guelph loam	4.5
Brady sandy loam	3.0
Fox sandy loam	6.5
Berrien sandy loam	6.5

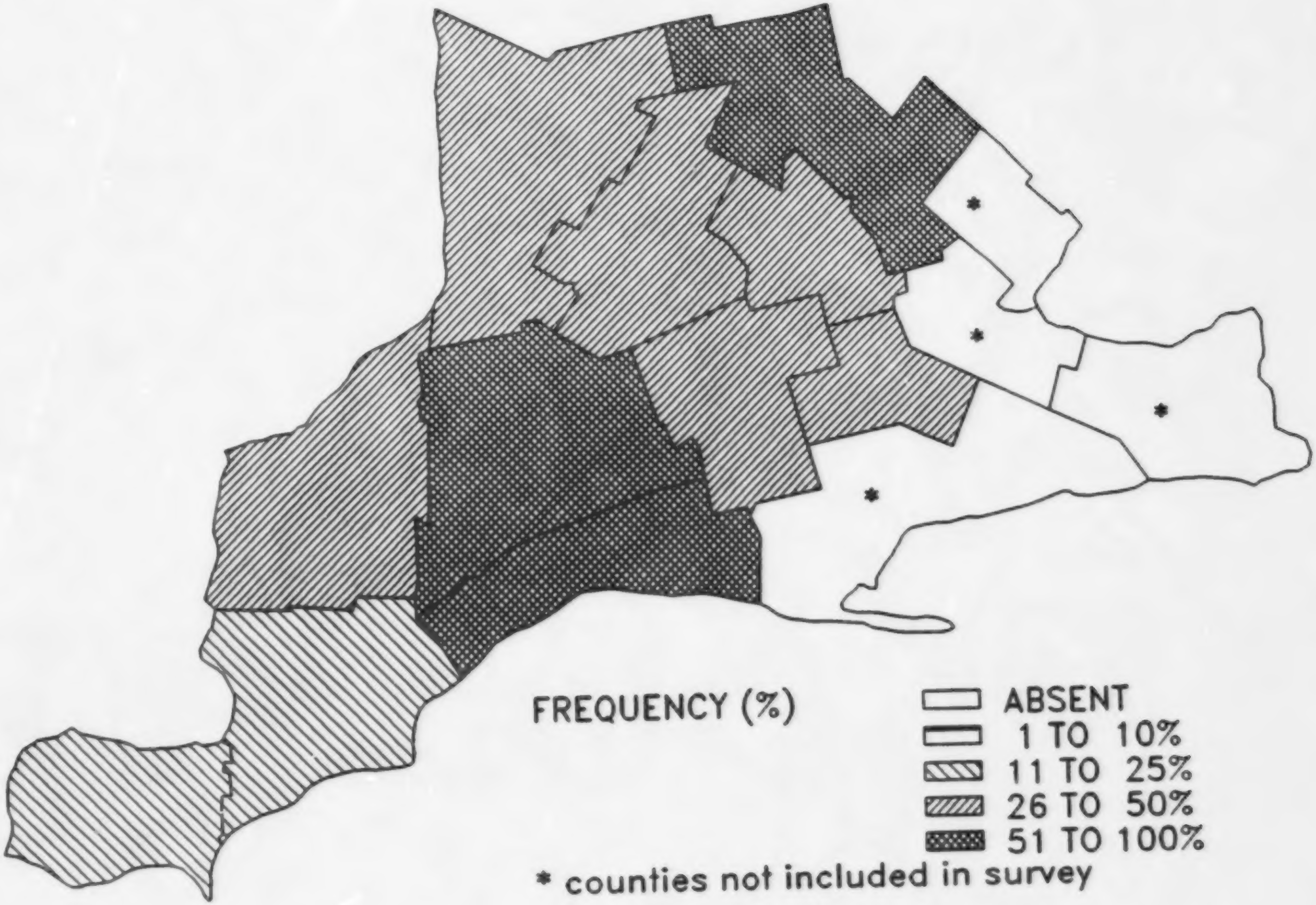
GREEN FOXTAIL



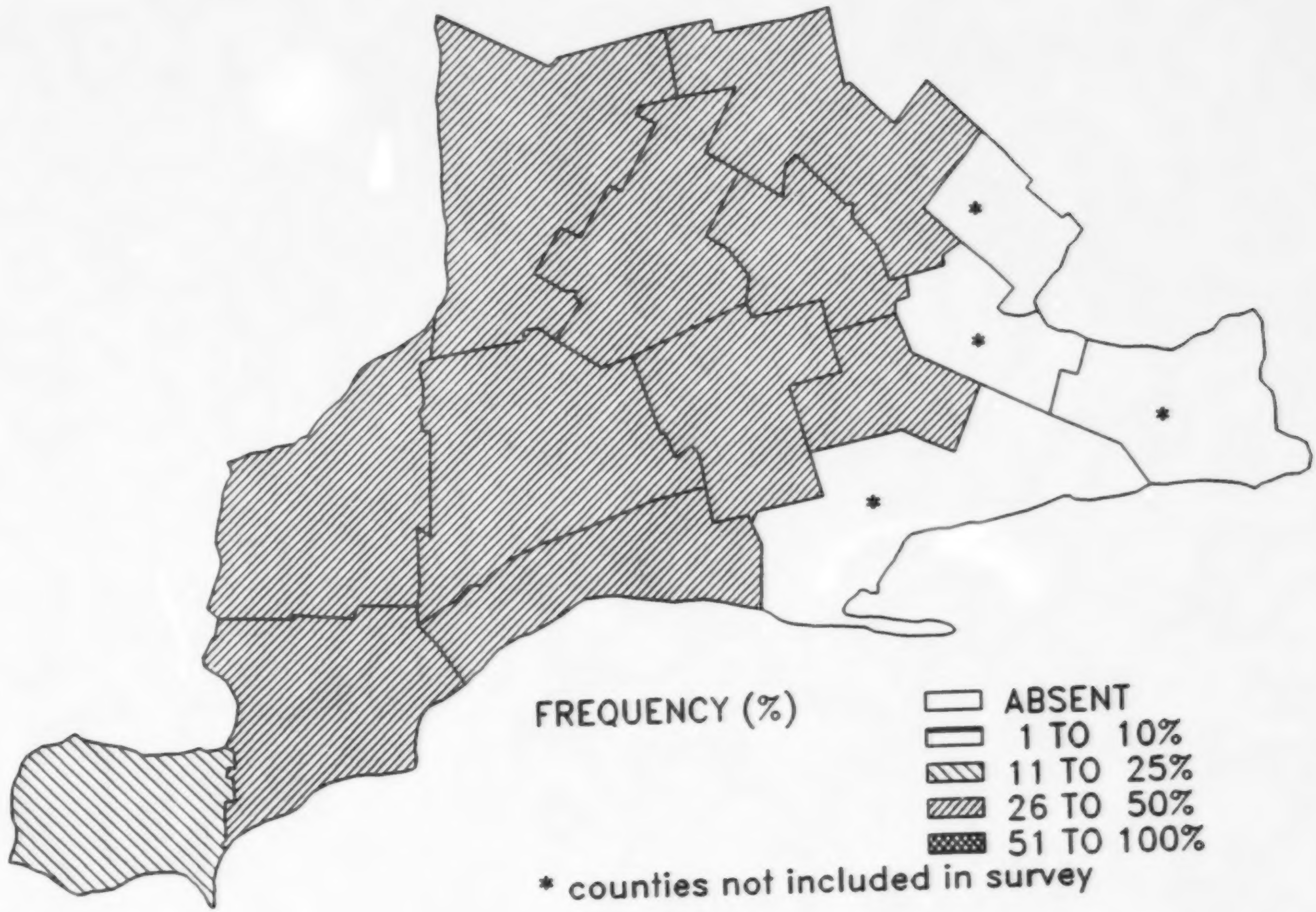
LAMB'S-QUARTERS



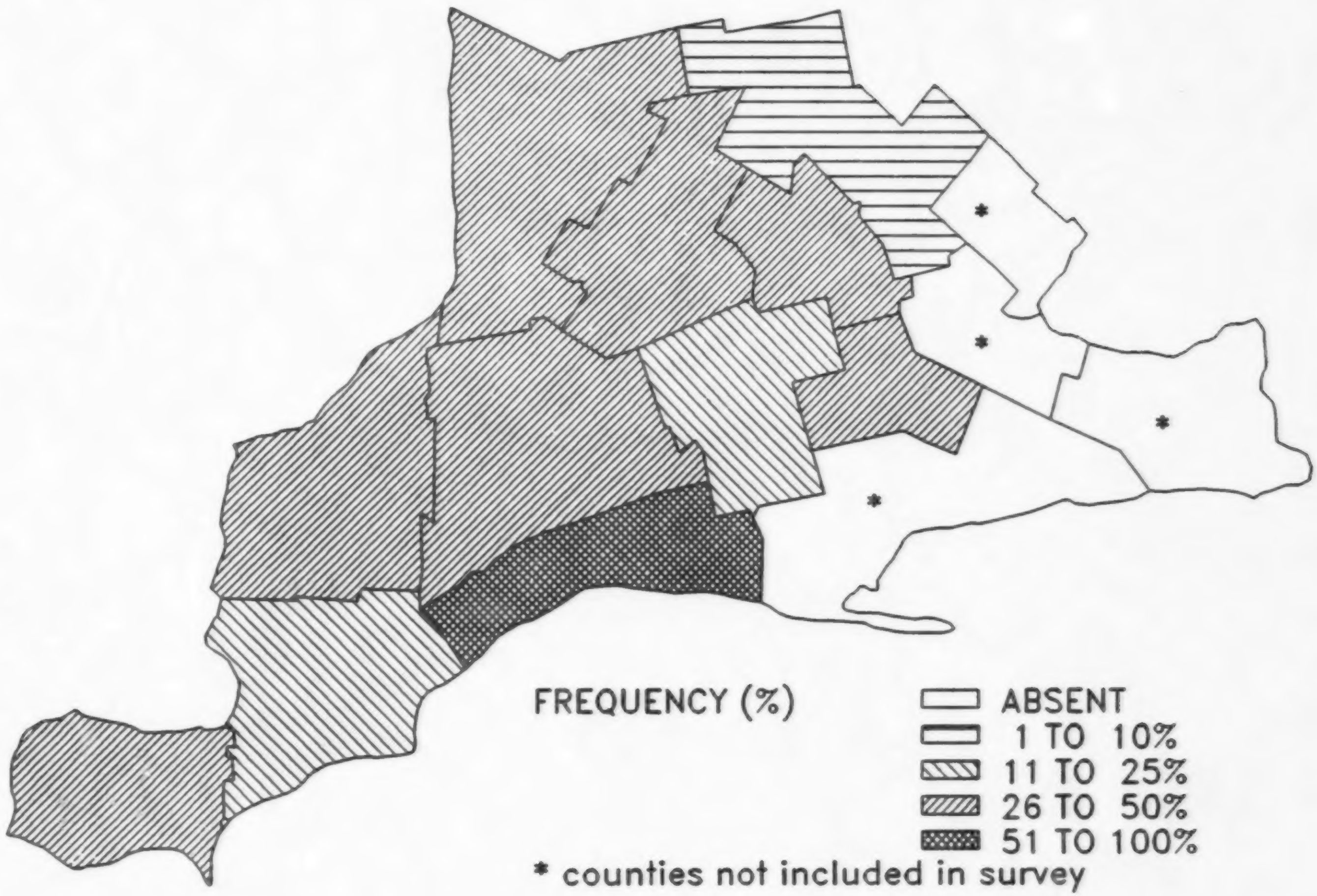
QUACK GRASS


FREQUENCY (%)
ABSENT
1 TO 10%
11 TO 25%
26 TO 50%
51 TO 100%
* counties not included in survey

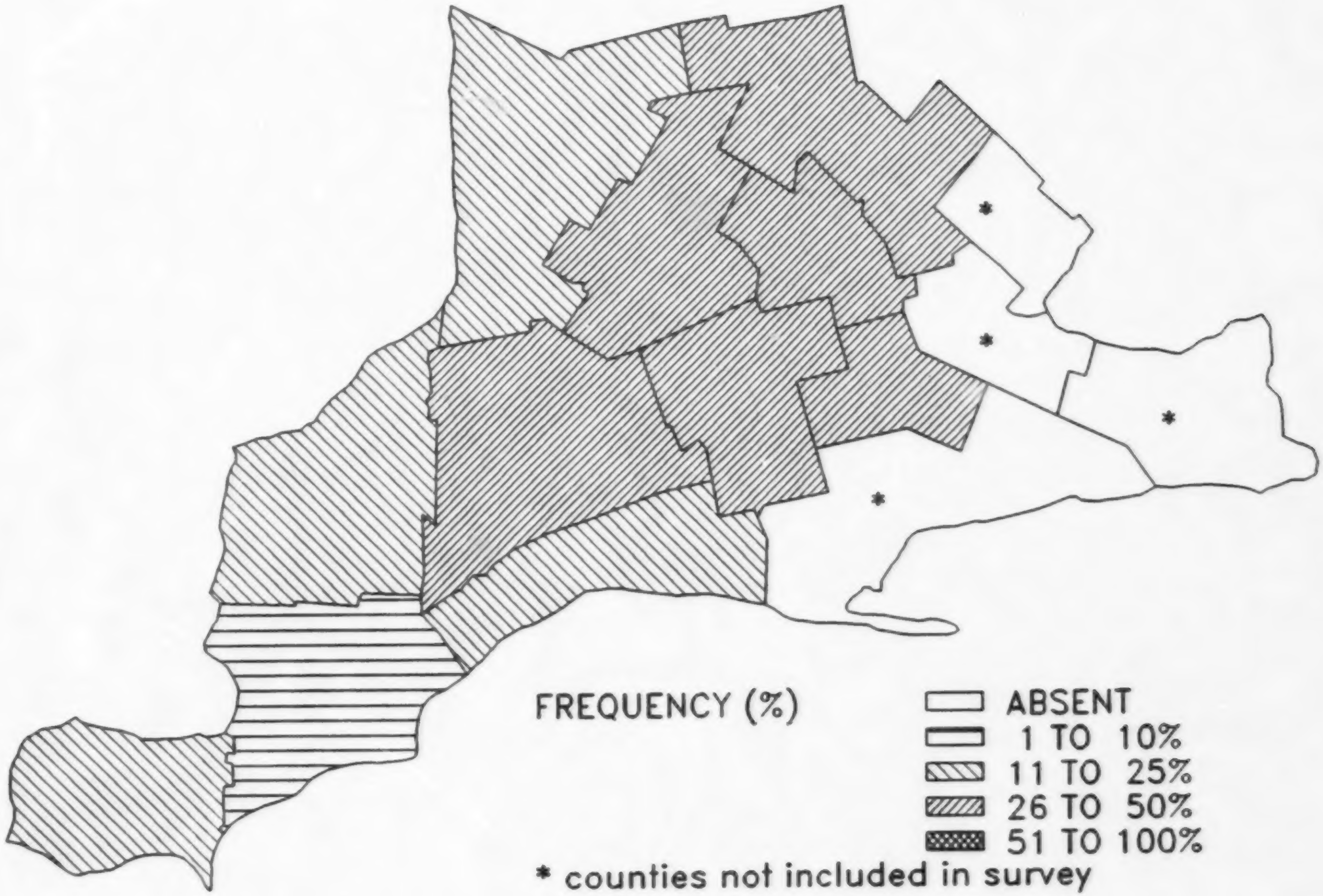
REDROOT PIGWEED



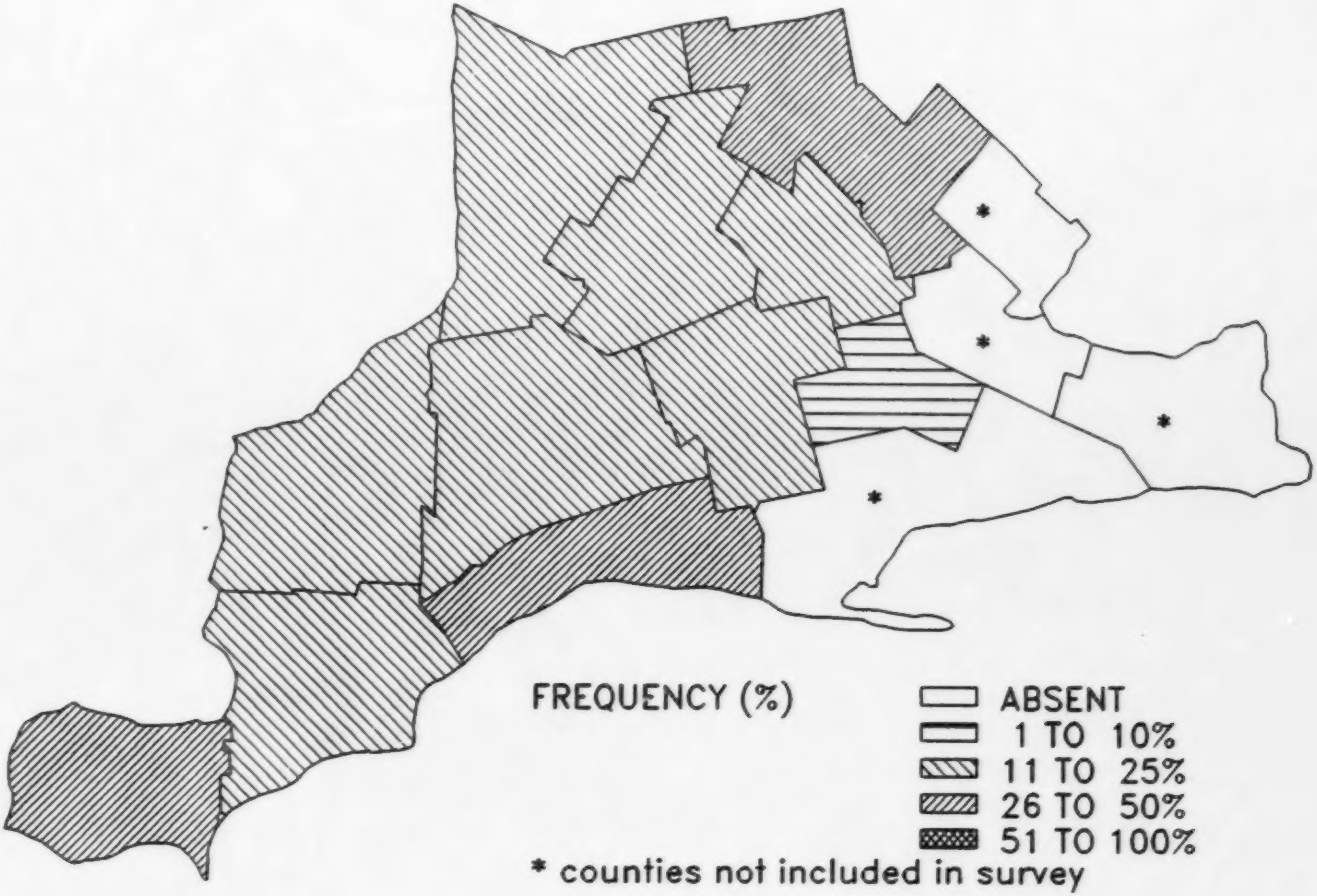
COMMON RAGWEED



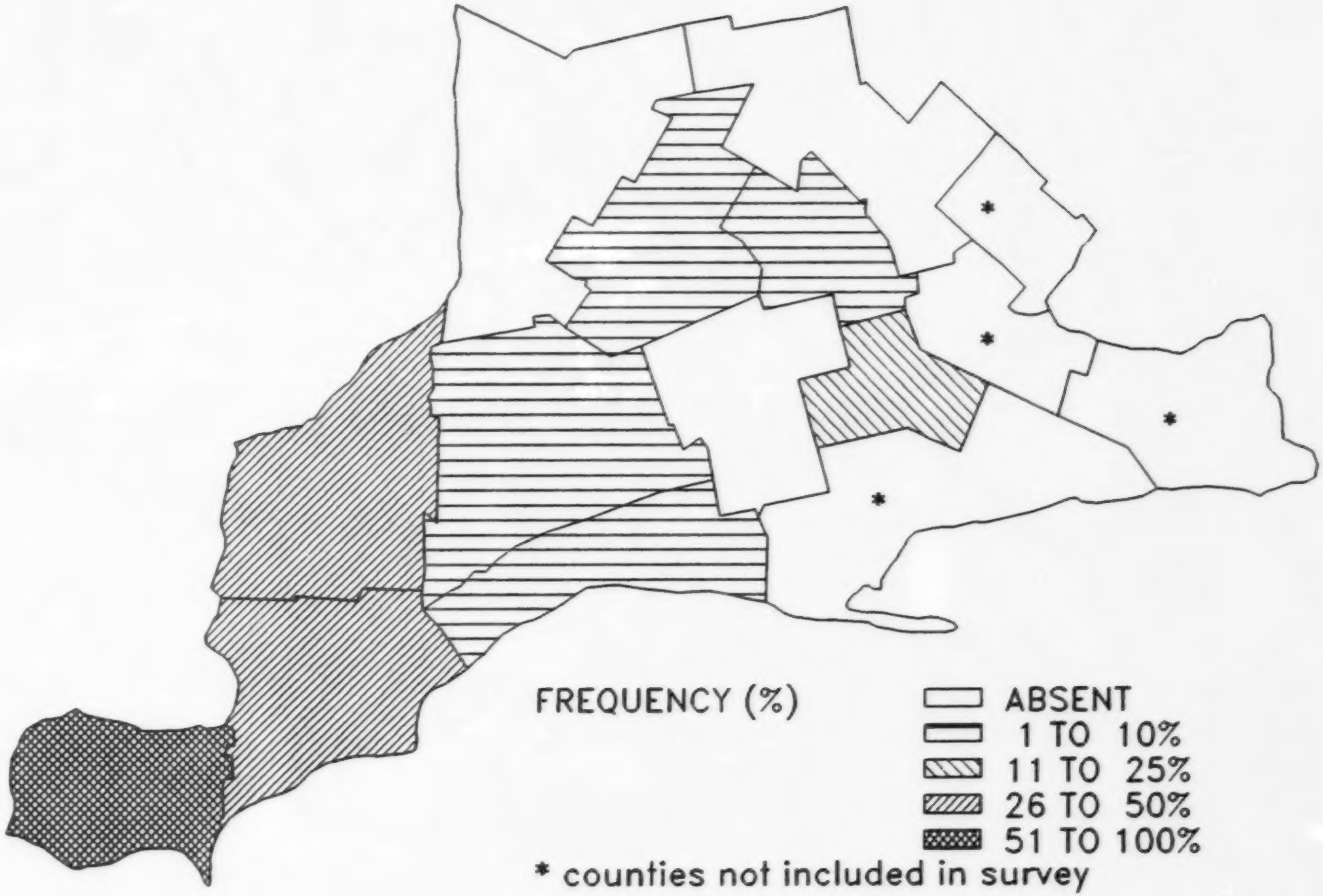
DANDELION


FREQUENCY (%)
ABSENT
1 TO 10%
11 TO 25%
26 TO 50%
51 TO 100%
* counties not included in survey

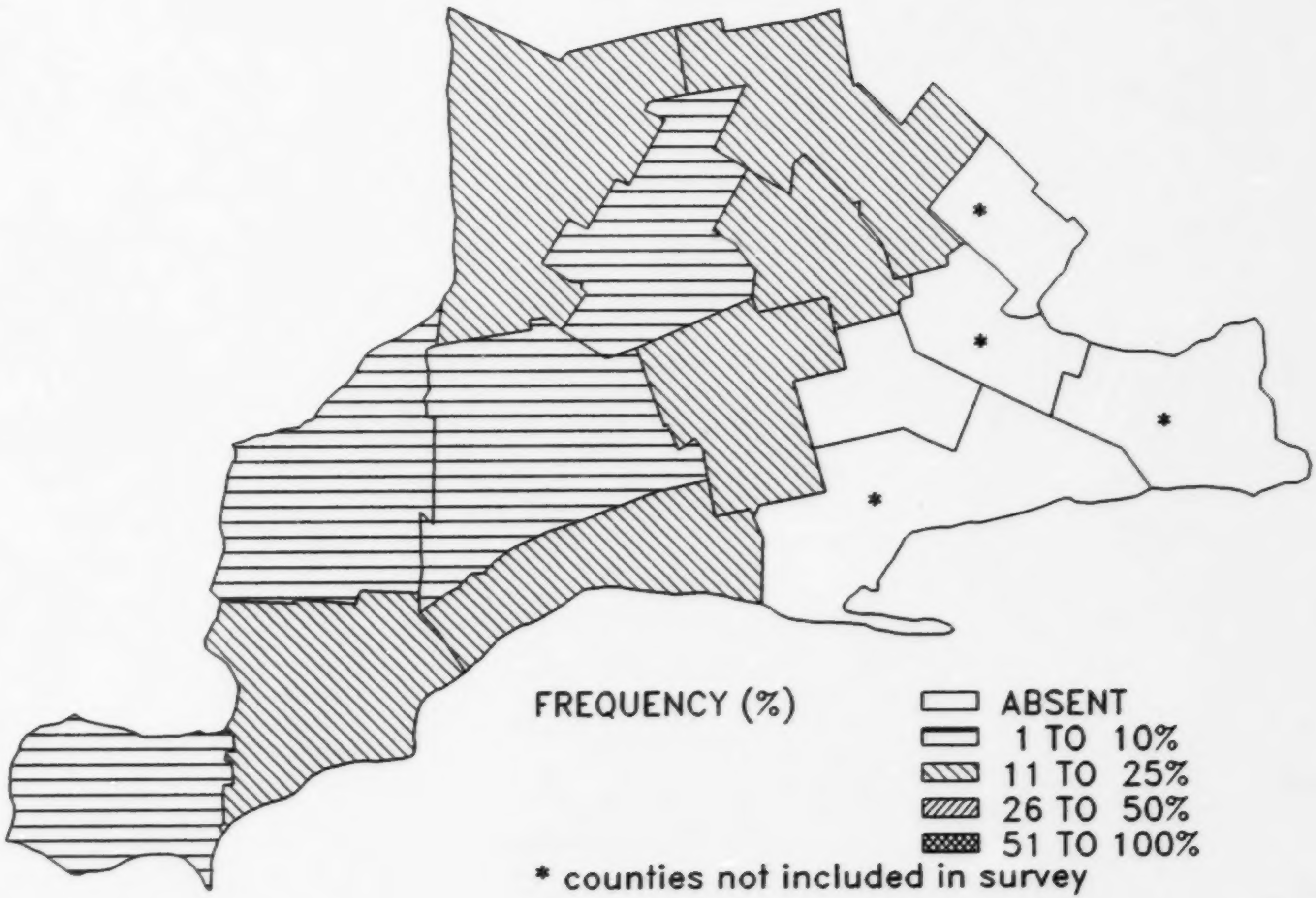
ANNUAL SMARTWEEDS



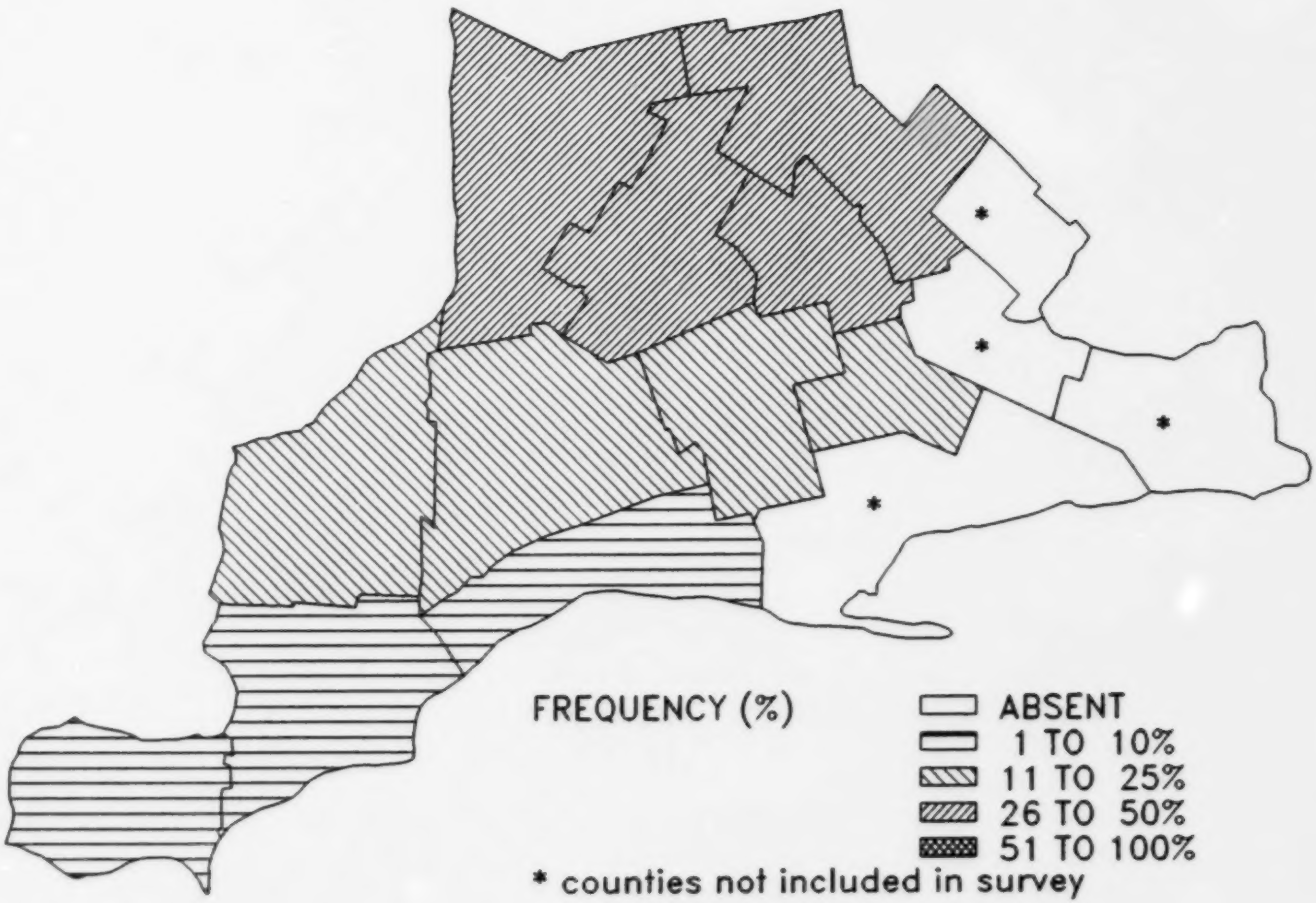
VELVETLEAF


FREQUENCY (%)
ABSENT
1 TO 10%
11 TO 25%
26 TO 50%
51 TO 100%
* counties not included in survey

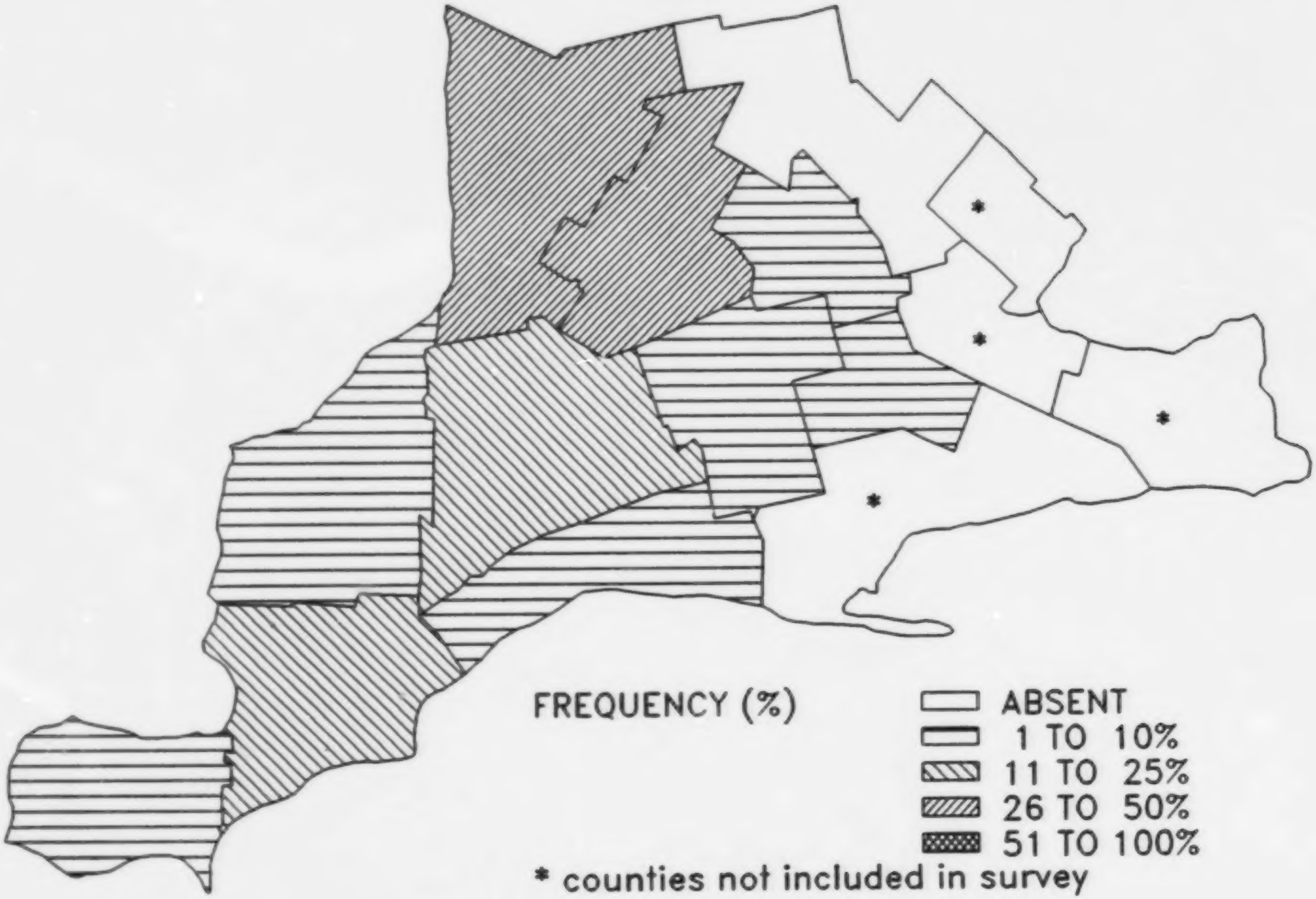
CRAB GRASSES



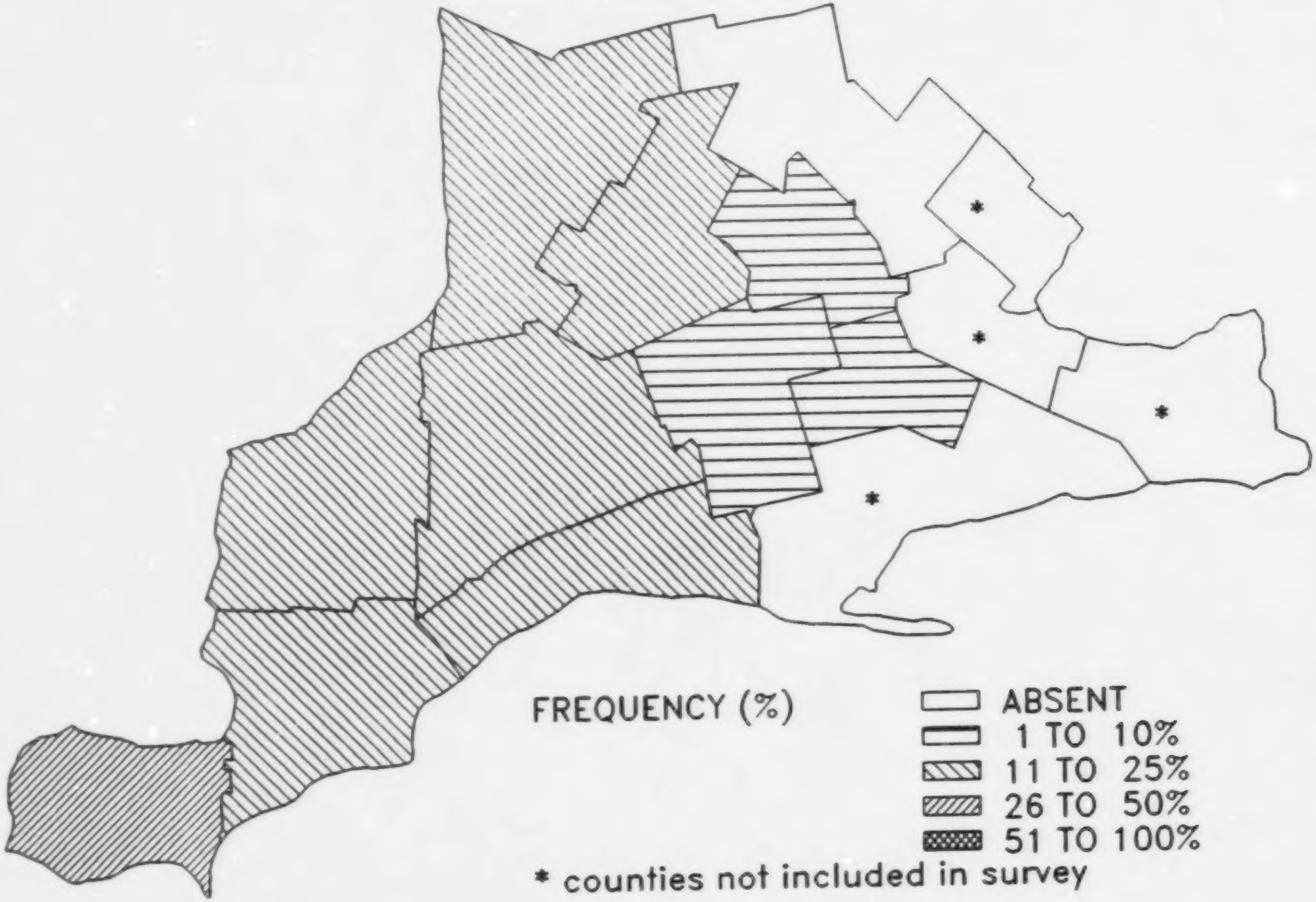
WILD BUCKWHEAT



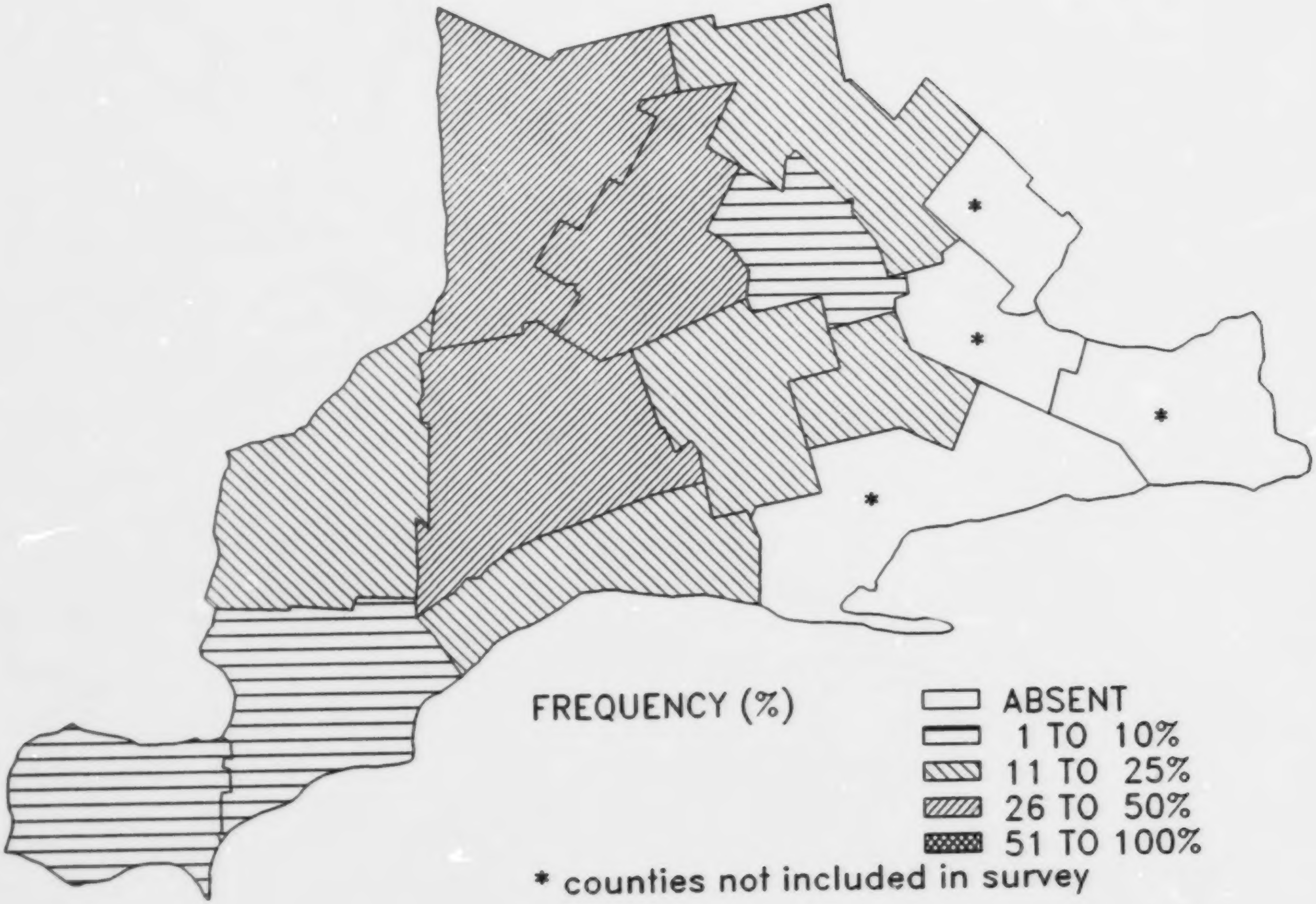
FIELD BINDWEED



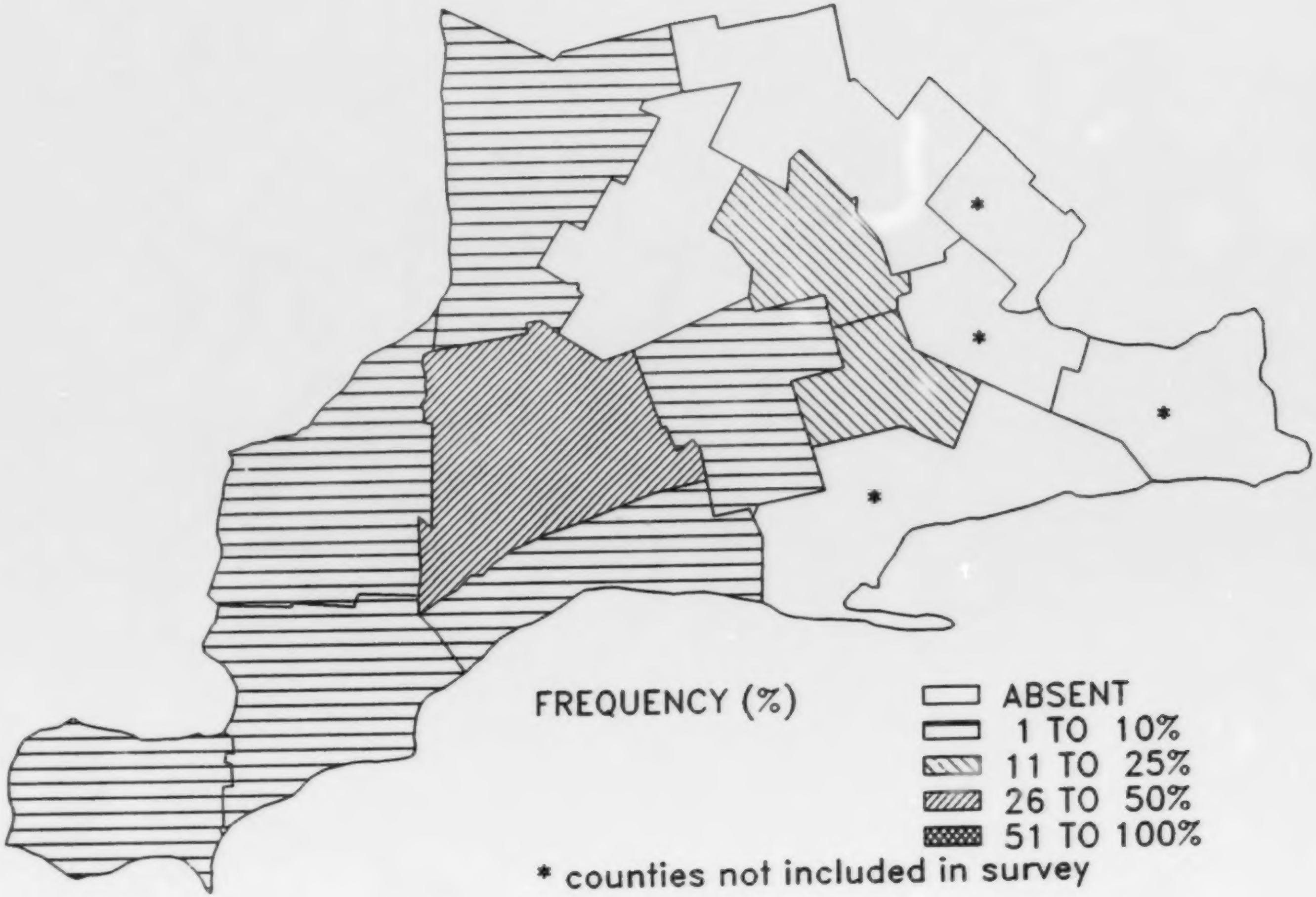
BARNYARD GRASS



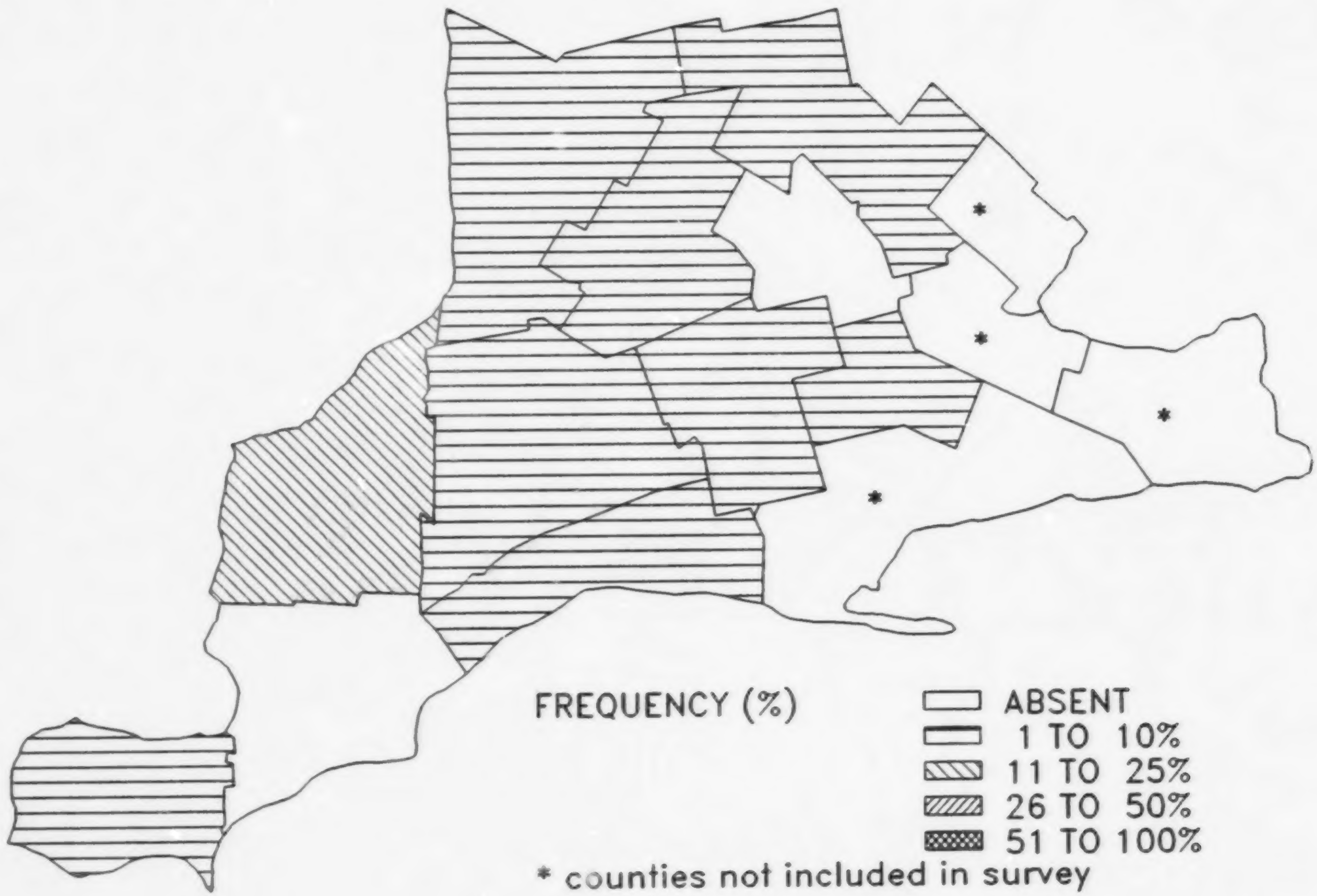
COMMON MILKWEED



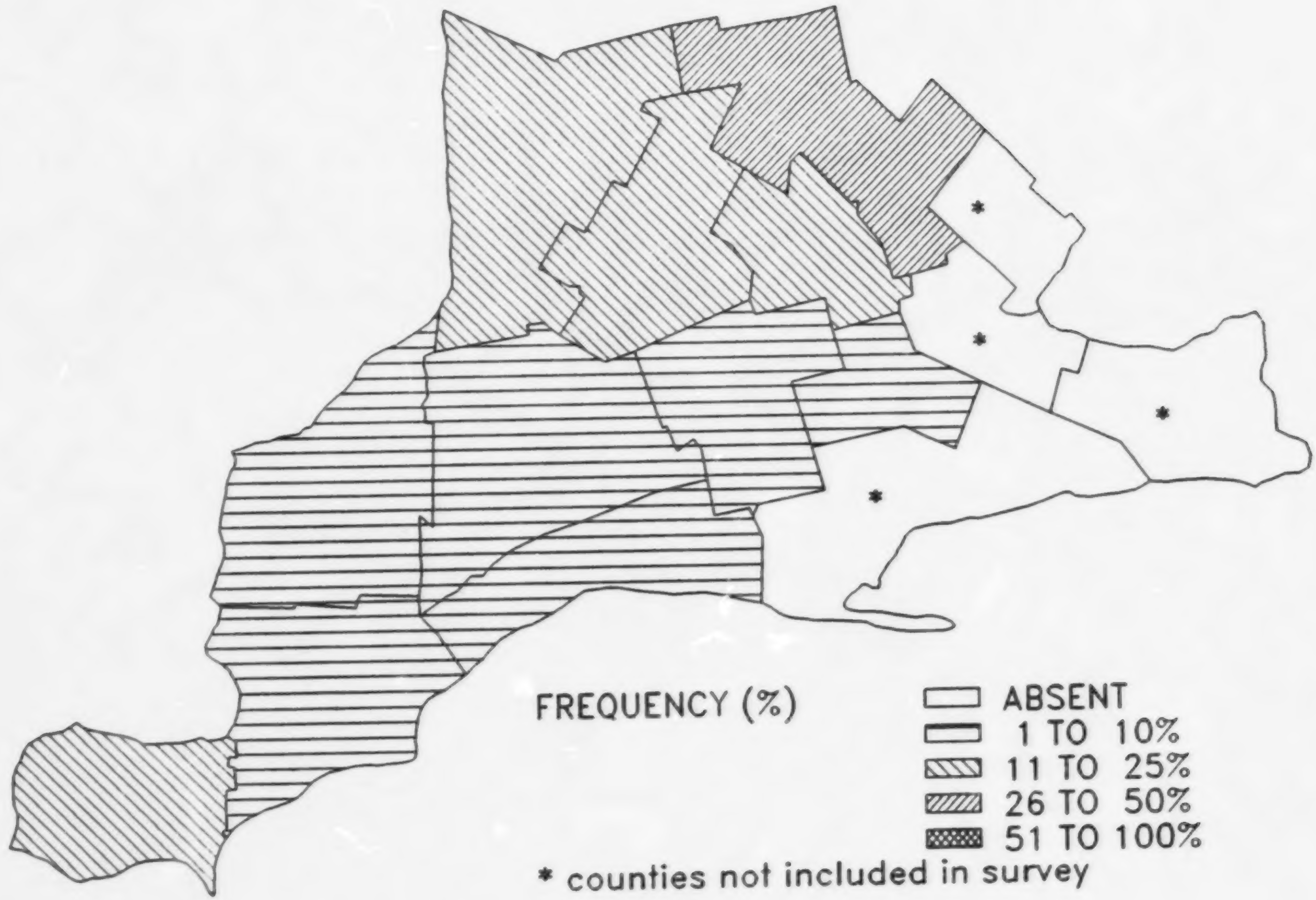
YELLOW NUT SEDGE



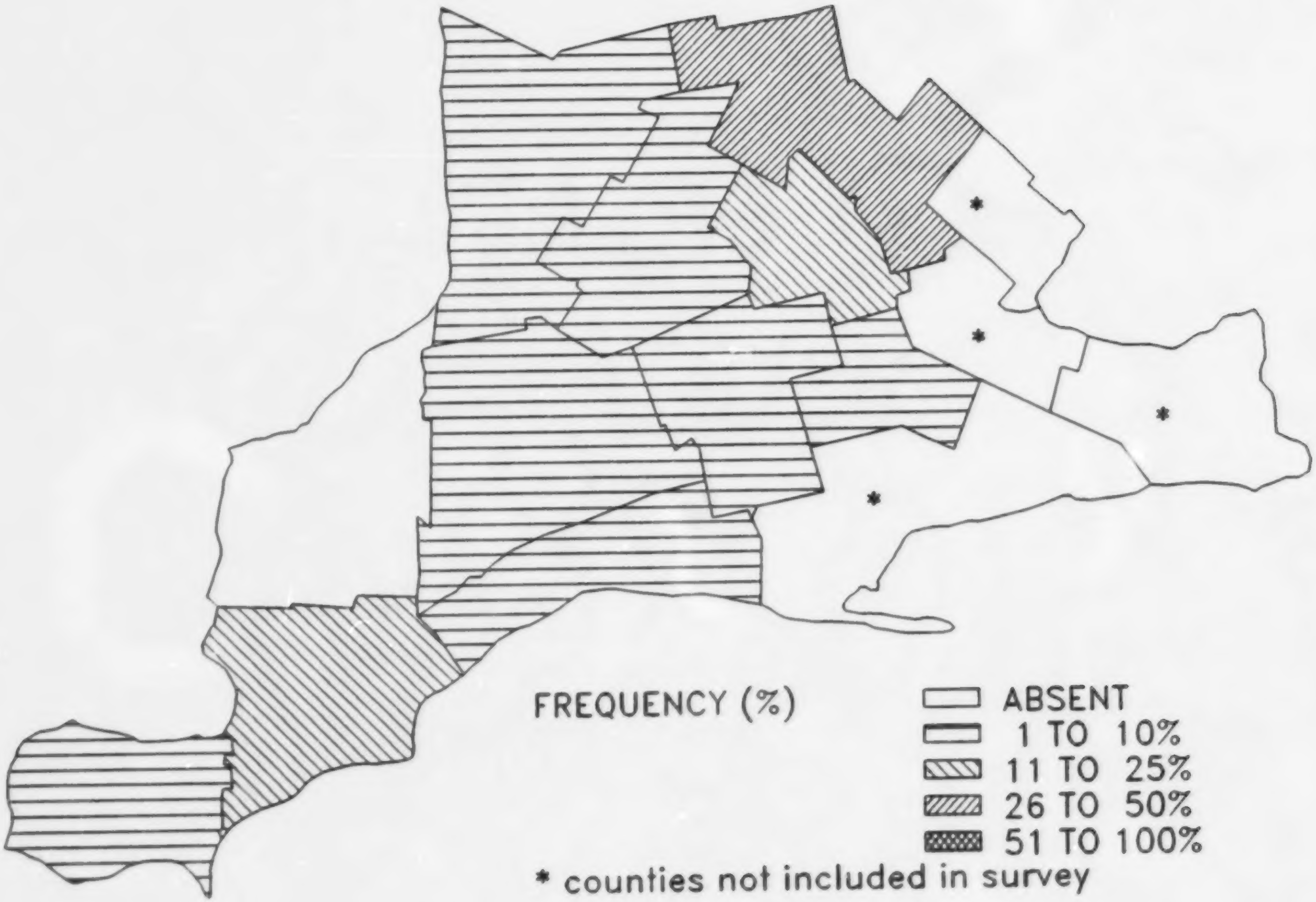
YELLOW FOXTAIL



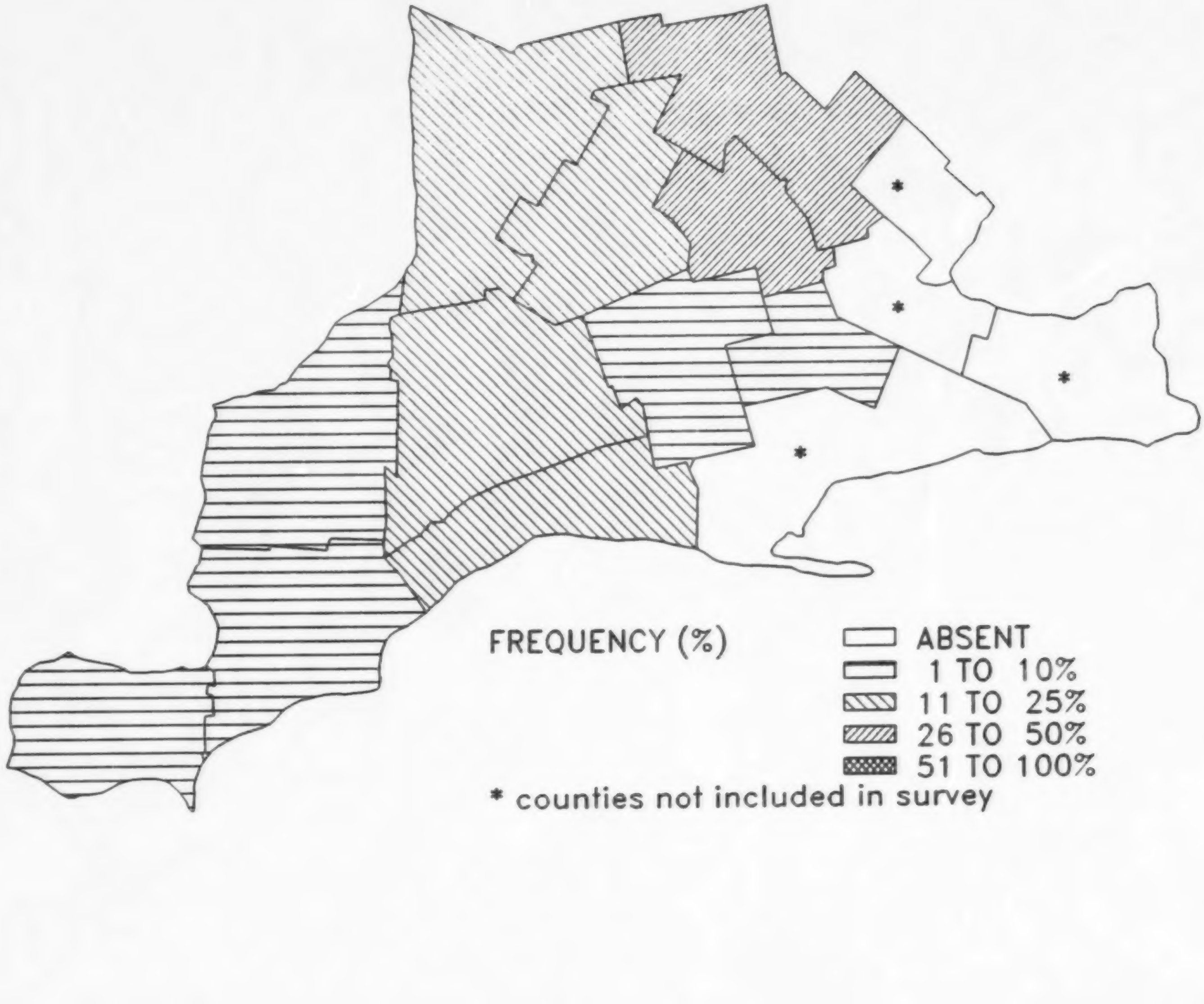
WITCH GRASS


FREQUENCY (%)
ABSENT
1 TO 10%
11 TO 25%
26 TO 50%
51 TO 100%
* counties not included in survey

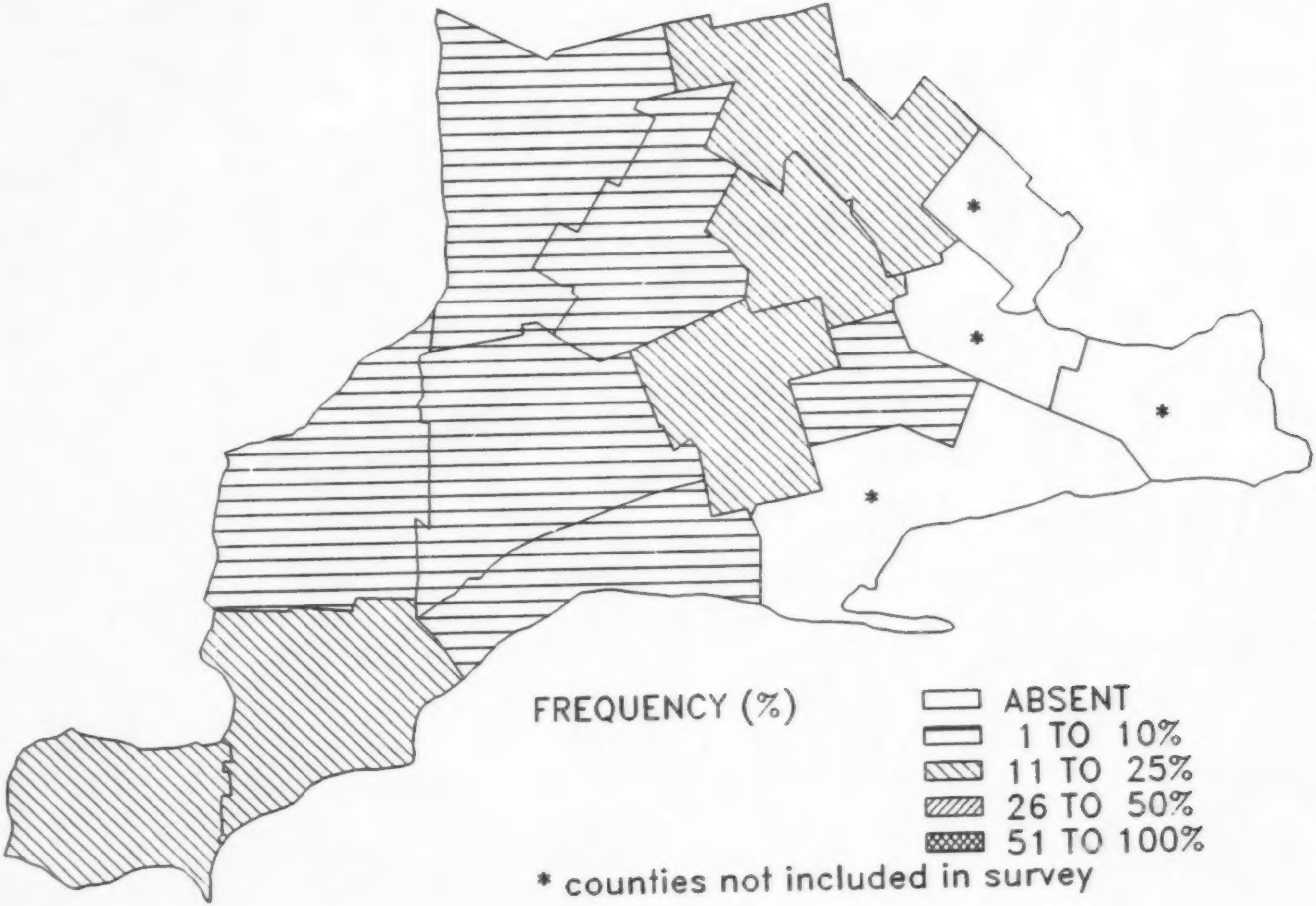
CHICKWEED


FREQUENCY (%)
ABSENT
1 TO 10%
11 TO 25%
26 TO 50%
51 TO 100%
* counties not included in survey

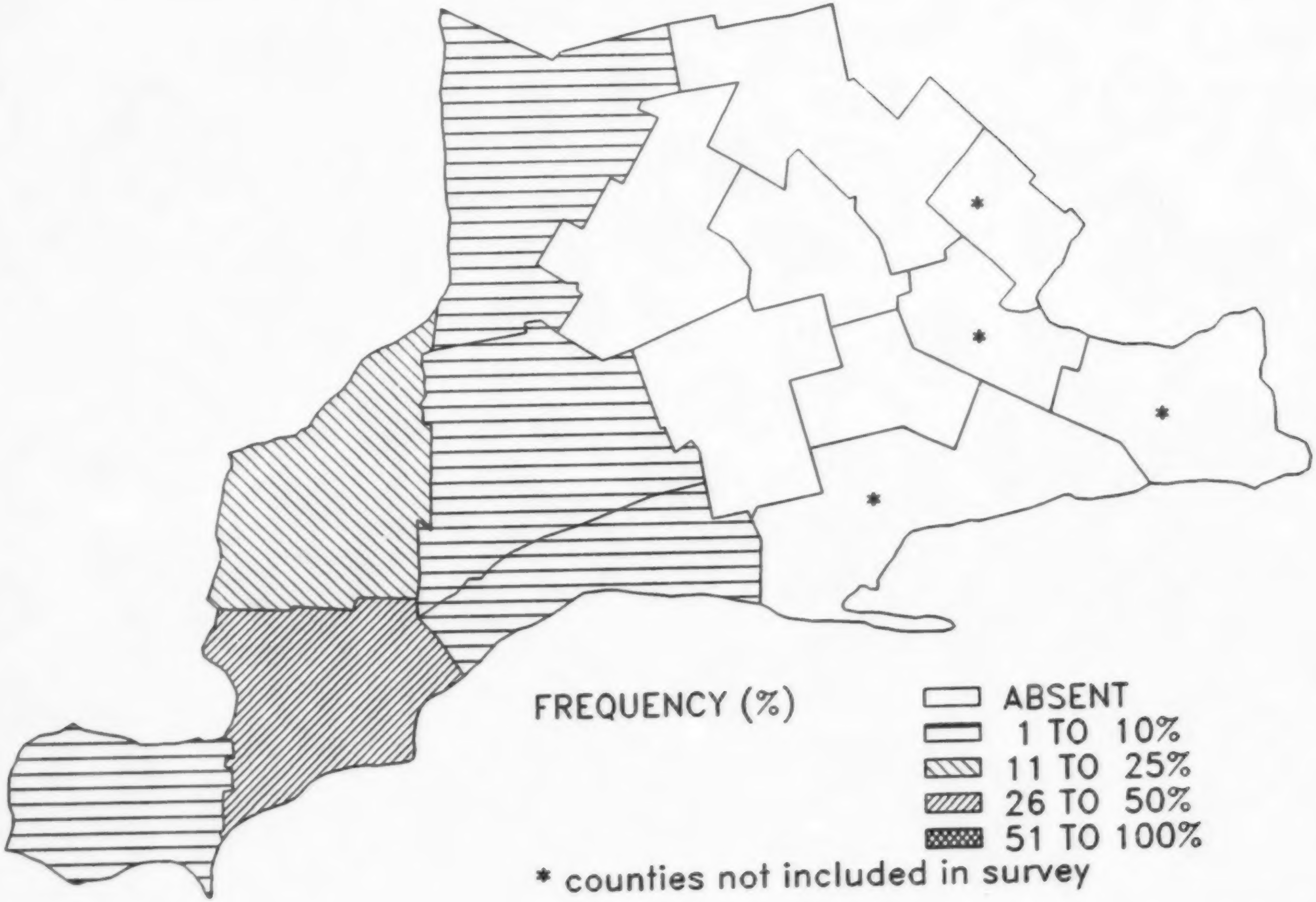
COMMON YELLOW WOOD-SORREL



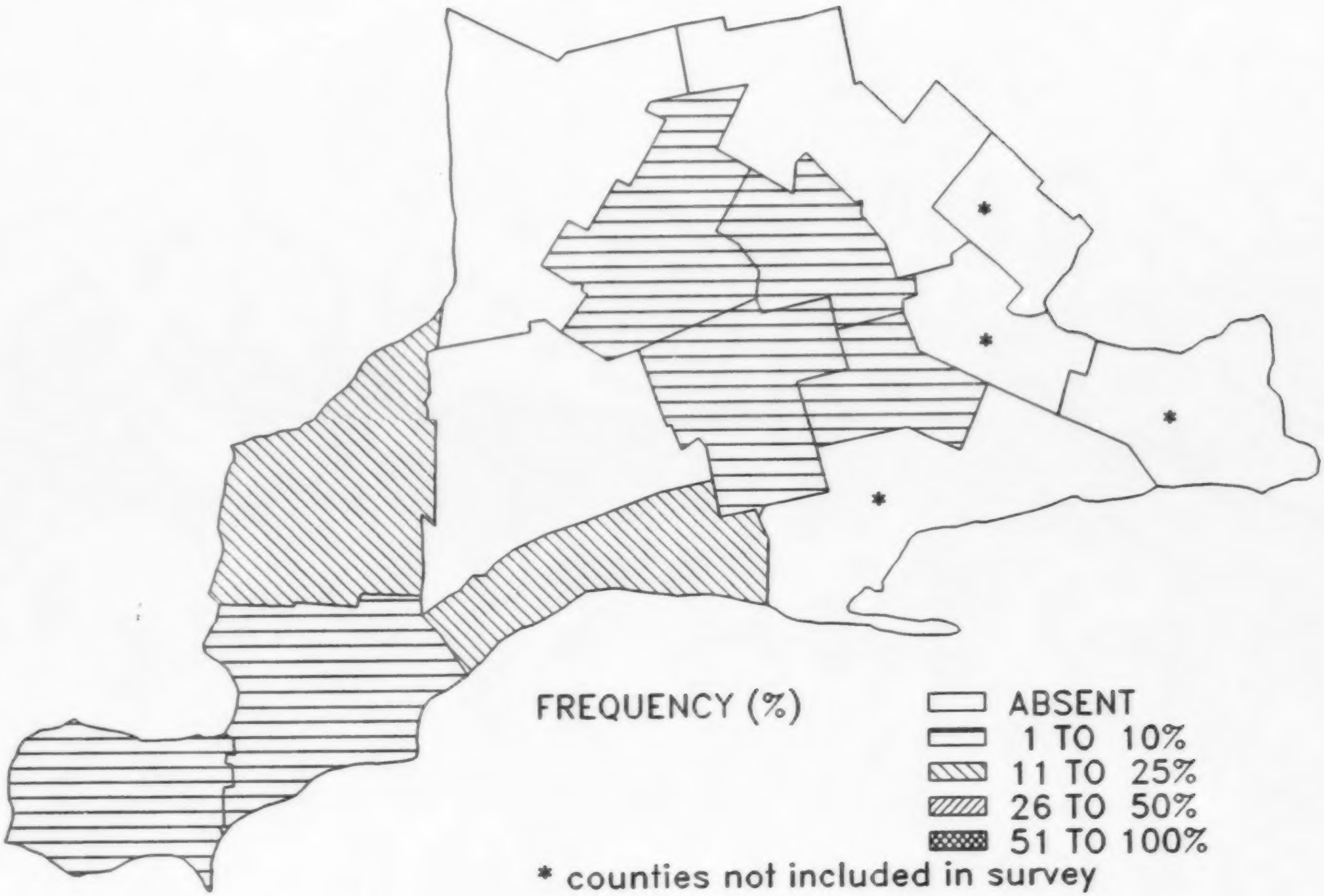
BROAD-LEAVED PLANTAIN



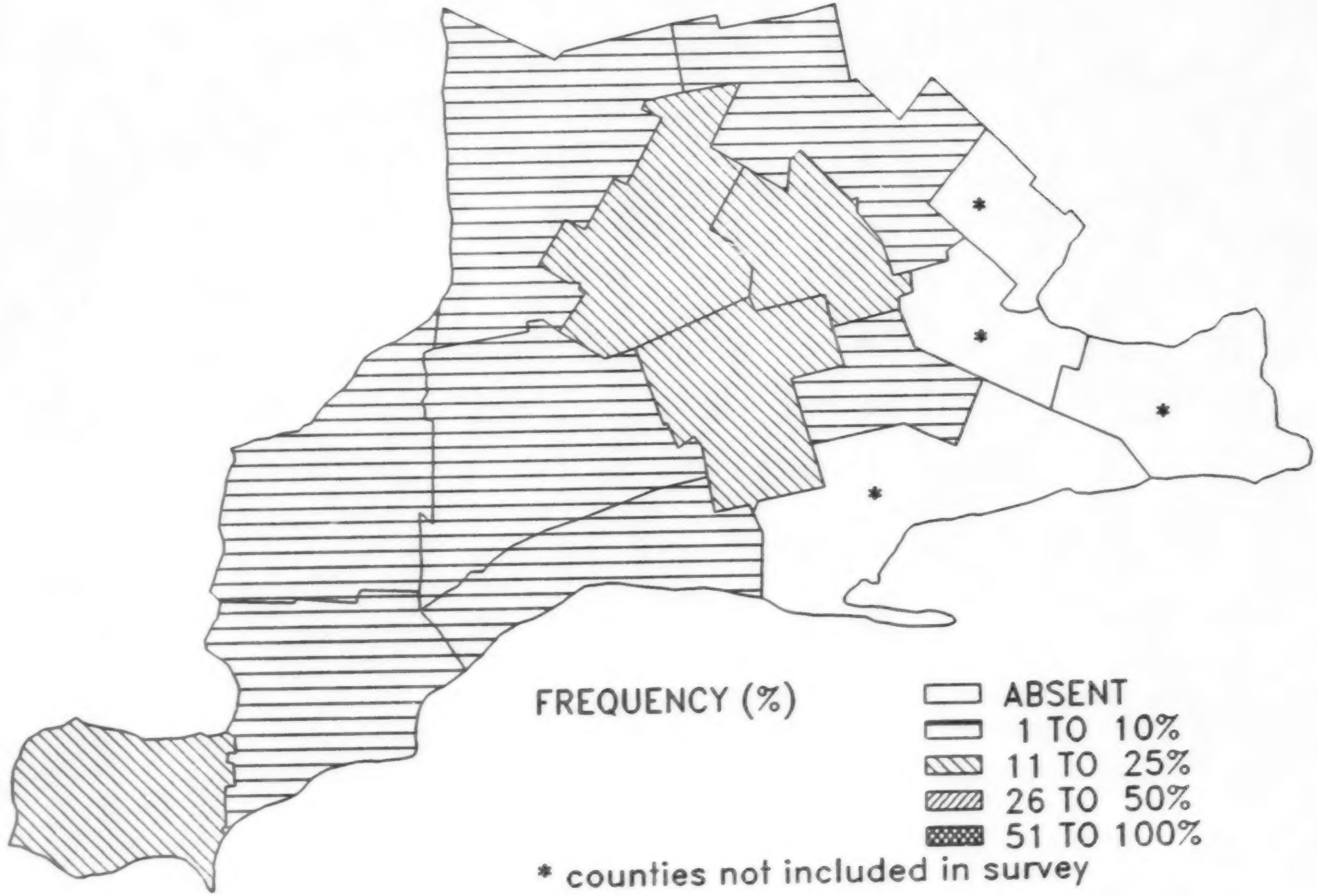
BLACK NIGHTSHADE



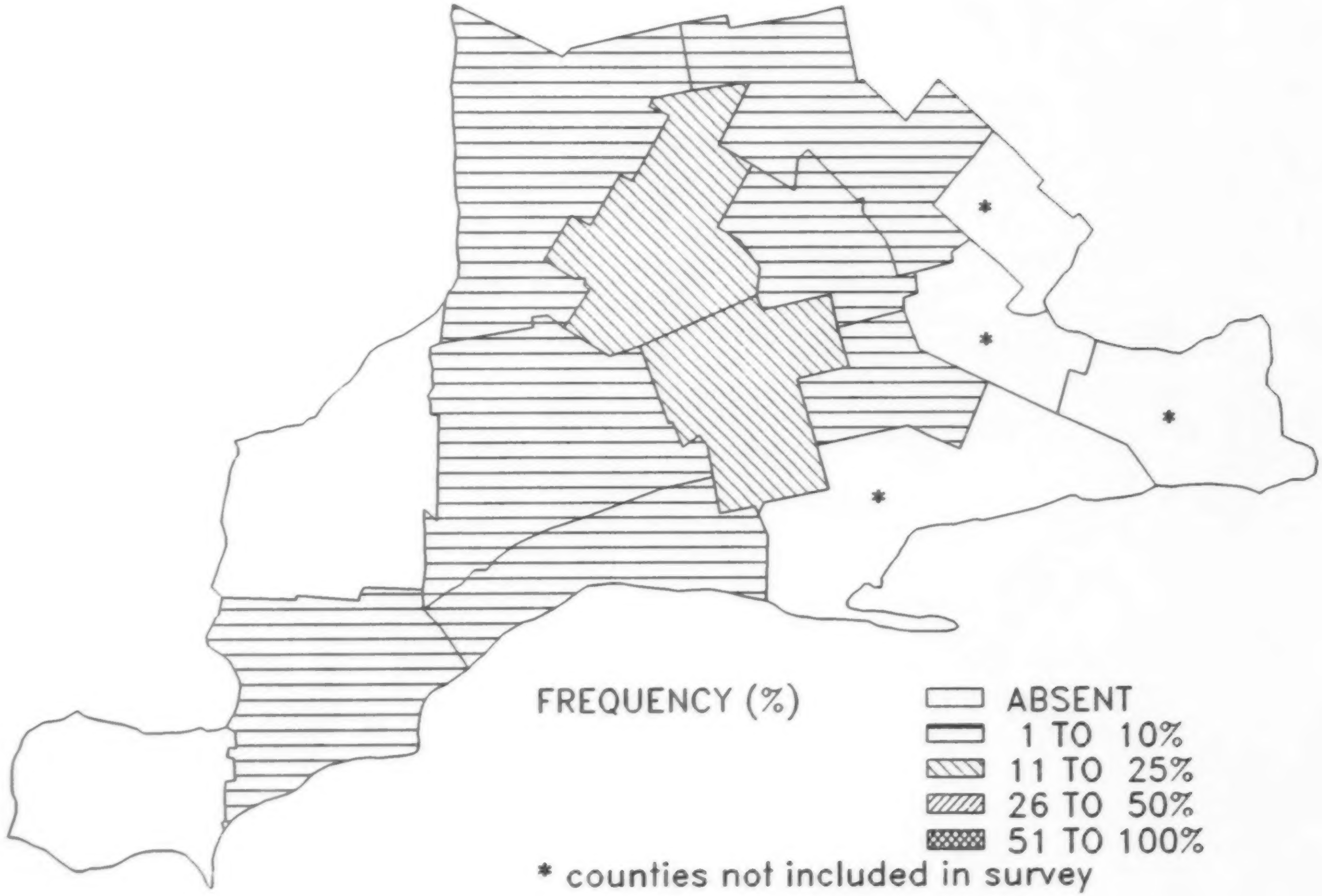
FALL PANICUM



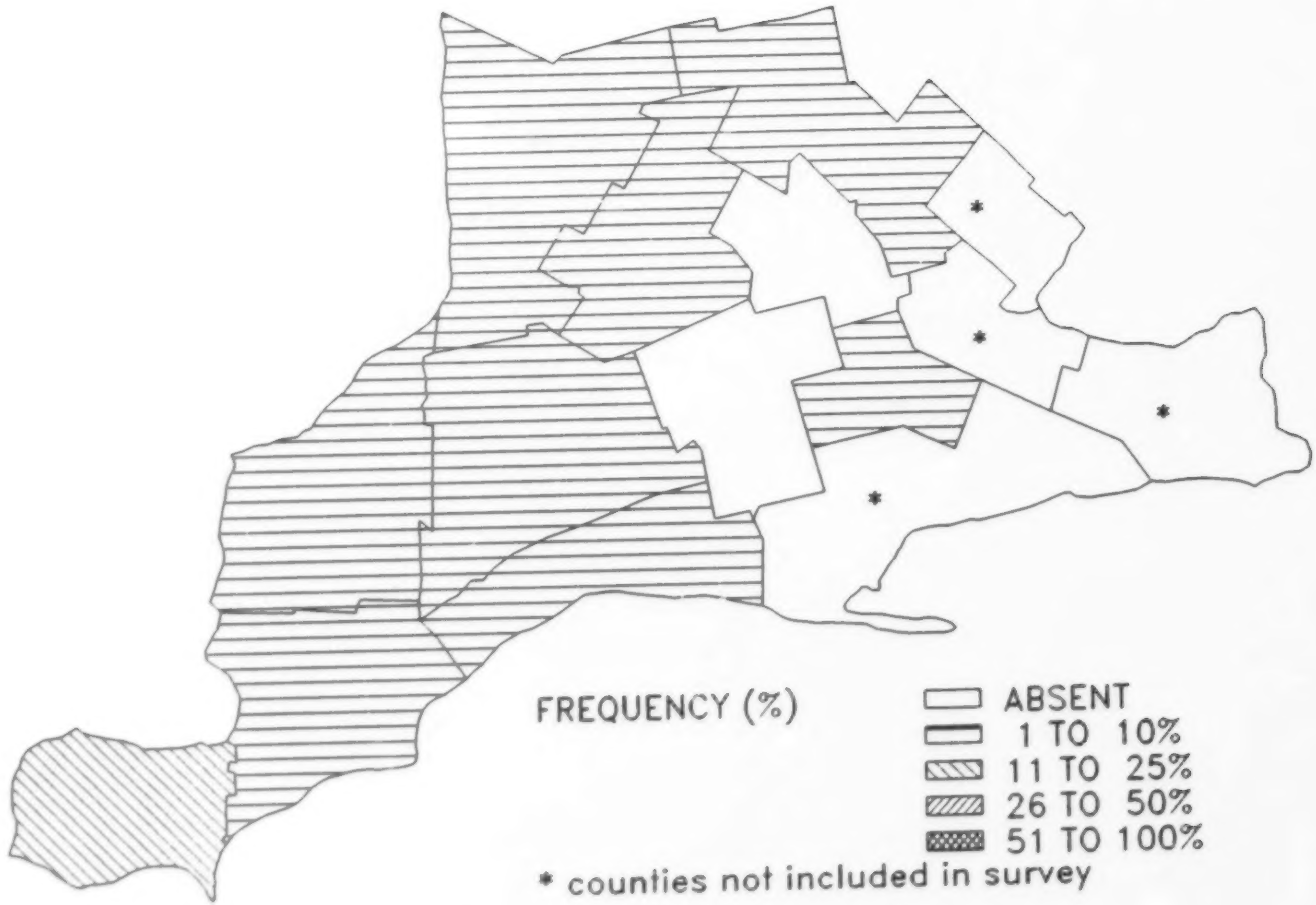
PROSTRATE KNOTWEED



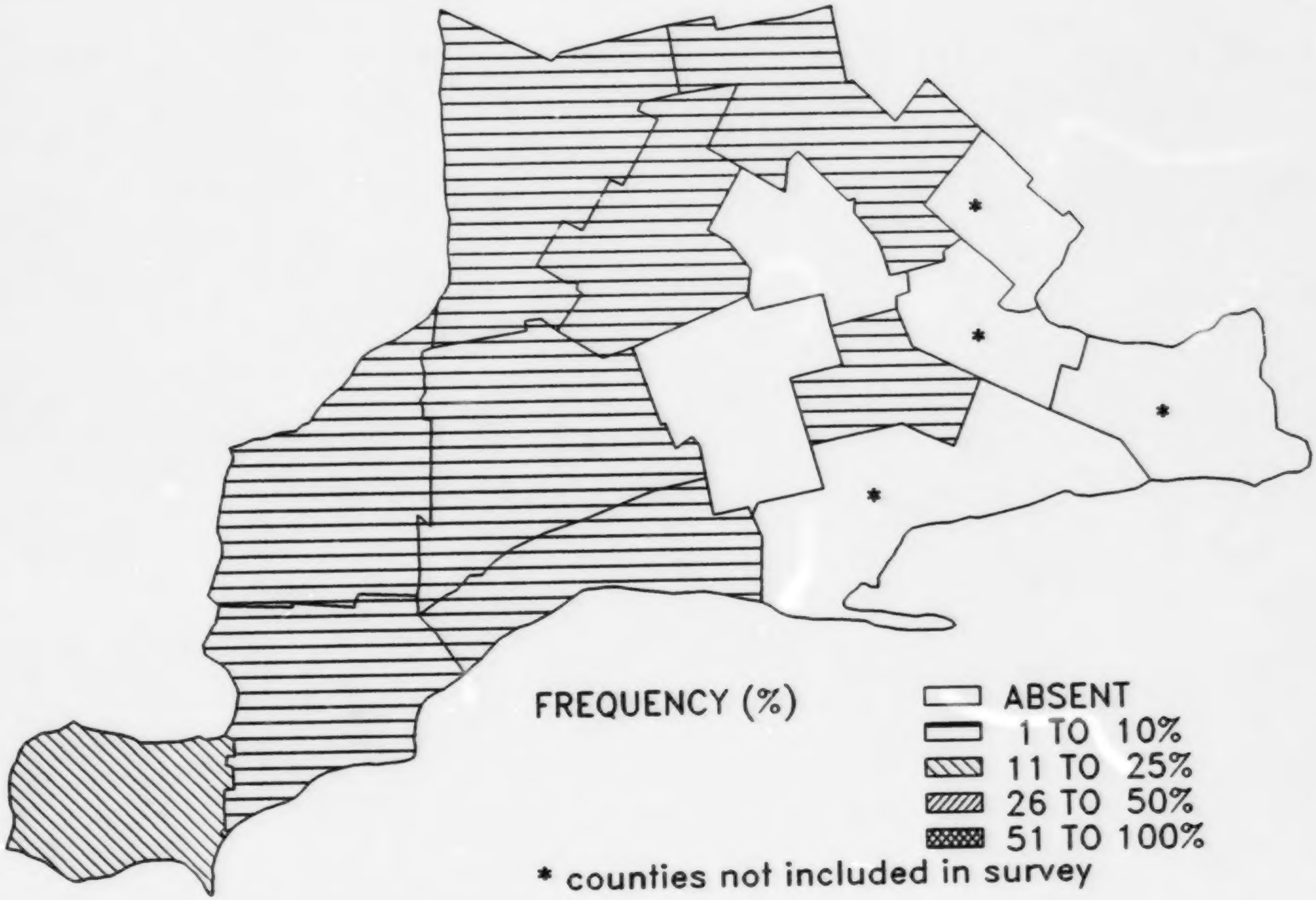
FIELD HORSETAIL



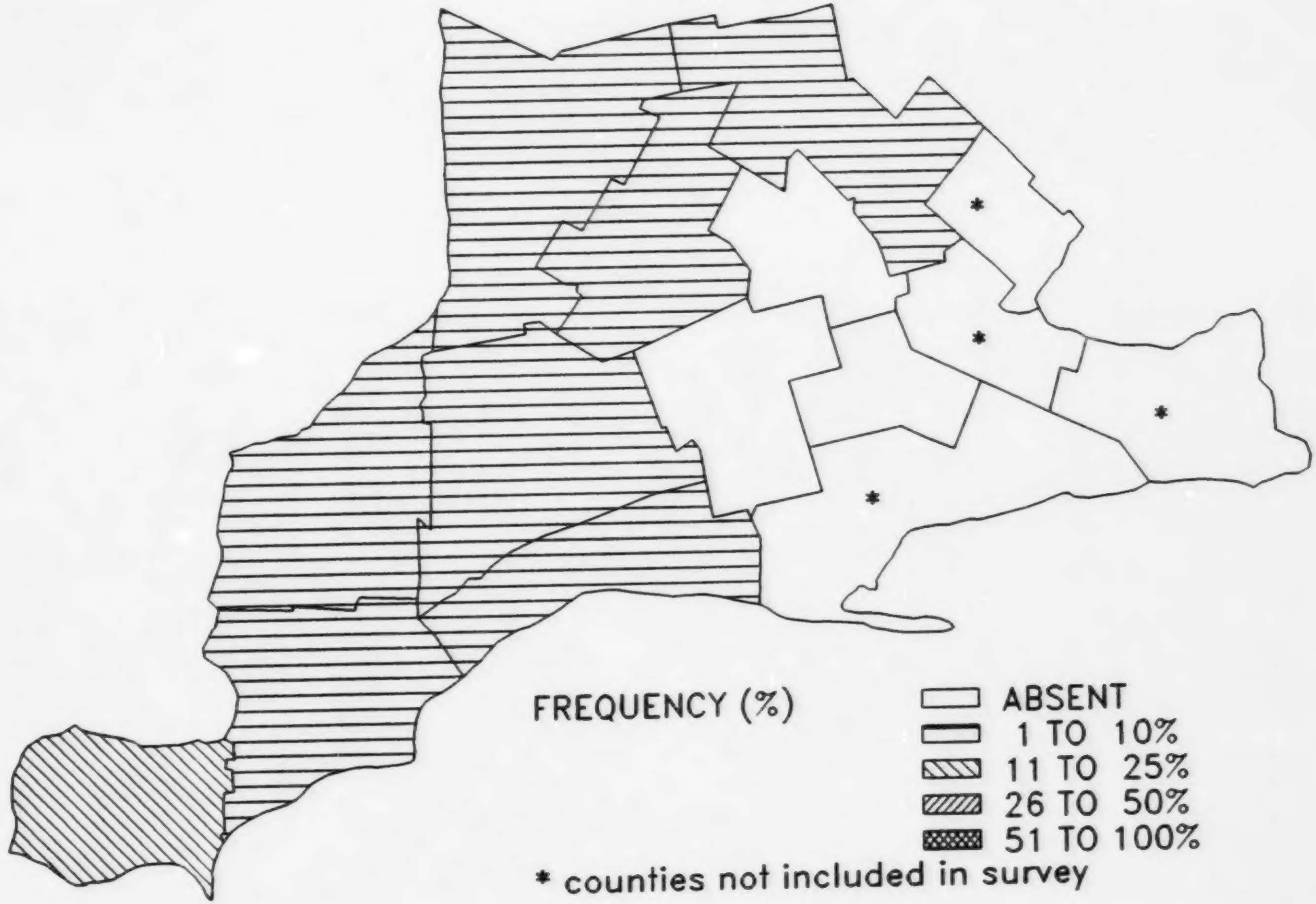
CANADA THISTLE



CANADA THISTLE



WILD CARROT


FREQUENCY (%)
ABSENT
1 TO 10%
11 TO 25%
26 TO 50%
51 TO 100%
* counties not included in survey

Discussion of the Field Survey Results

We recorded 82 weed types in the 593 fields surveyed. Most of these were single species, but some such as annual smartweeds and crab grasses represent congeneric groupings that were difficult to distinquish in the field. Many weeds were relatively rare. Fifty-eight weeds had relative abundance values less than 2.5 and accounted for only 10% of the total relative abundance (Table A1). Another 17 species had a relative abundance between 2.5 and 10, accounting for 32% of the total. Only seven species were found with a relative aundance greater than 10: green foxtail, lamb's-quarters, quack grass, redroot pigweed, common ragweed, dandelion and annual smartweeds. These seven species accounted for 58% of the total relative abundance. A weed flora dominated by few species is common for communities sampled after control measures have been used.

Most of the species with relative abundance values greater than 10 also had high values for each of the components of relative abundance: frequency of occurrence, field uniformity and density. A notable exception is dandelion, which had a relatively low value for density in fields where it occurred. Several species had relatively high values of only one of the components of relative abundance. Two species, volunteer corn and green pigweed had relatively high values of frequency (greater than 5% of fields) but had relative abundance values less than 2.5. Seven species had relatively high values of occurrence field uniformity (between 19 and 33%), and yet had relative abundance less than 2.5. These were cocklebur, field violet, alfalfa, mouse-eared chickweed, wild oats, bouncingbet, and black medick. Eight species had relatively high values of occurrence field density (greater than 2.5 per m^2) and yet relative abundance less than 2.5. These were volunteer winter wheat, giant foxtail, clovers, Canada thistle, timothy, wild oats, field violet and cocklebur. Many of these species with high densities were grasses. Yellow foxtail, common chickweed, and crab grasses had average occurrence densities greater than 10 plants/m^2. Yellow foxtail and crab grasses were found at densities greater than 200 plants/m^2 in one or more fields.

Weed communities were not qualitatively different among tillage systems. Conventional fields had a total of 61 species; conservation fields had a total of 69; no-till fields had a total of 68. The species that were not common to all three tillage systems were very minor species in the tillage systems in

which they did occur. All three tillage systems were dominated by five species that occurred in greater than 25% of fields (Table 11). These were green foxtail, lamb's-quarters, redroot pigweed, common ragweed, and quack grass. Dandelion also occurred in greater than 25% of fields managed with a conservation or no-till system while it occurred in only 22% of fields managed with a conventional system. The relative frequency for a weed group did not differ markedly among tillage systems.

Weed communities differed in density among the tillage types. The average combined density of all weeds over all fields and tillage systems was 25 plants/m^2. The average combined density of all weeds in a conventional tillage system was 17 plants/m^2, in a conservation system was 25 plants/m^2, and in a no-till system was 32 plants/m^2 (Table 12). In other words, no-till fields had about the same weeds as conventionally tilled fields, but they had approximately twice as many of then. The fields managed with a no-till system had the highest densities for each of the weed groups.

There was a consistent trend toward decreased frequencies of perennial weeds, and decreased frequencies of annual grasses with time in conservation tillage (Table 13). Weed frequencies showed few consistent trends over the length of time that a no-till system was used (Table 14). Total density of weeds and the densities of the various weed groups tended to decrease with time in conservation tillage (Table 15). Density of minor species was greater in established no-till than in other systems, and greater in later than in earlier years of no-till.

Weed frequencies differed among crops (Table 16). Winter wheat fields had the largest frequency values for common ragweed, annual smartweeds, wild buckwheat, common yellow wood-sorrel, prostrate knotweed, and broad-leaved plantain. Redroot pigweed and velvetleaf were least frequent in winter wheat fields.

Weed communities differed in density among the crops (Table 17). Average combined densities of all weeds were 25 plant/m^2 for corn, 16 plants/m^2 for soybean and 40 plants/m^2 for winter wheat. Soybean fields had lower weed densities than corn fields, which in turn had lower weed densities than winter wheat fields for each of the major weed groups.

Tillage system had an effect on the frequencies of weeds in different crops (Tables 18-20). Dandelion occurred with a greater frequency in no-till fields than in fields that received some tillage, regardless of the crop.

Annual grasses were of more importance in corn fields than they were in other crops (greater relative frequency for the group). Soybean fields had the lowest total weed density for each of the tillage systems (Table 21). Winter wheat had a high total density of weeds in each tillage system. These trends were true for most of the weed groups.

Weed frequencies were similar in fields that had different previous crops (Tables 22 - 24). No-till fields that followed a cereal crop had very high total densites of weeds (Table 25). The annual broad-leaved, perennial and minor species weed groups were much higher in these no-till fields. Conventionally tilled fields generally had lower densities of annual weeds than conservation or no-till fields, regardless of the previous crop.

There were some trends in weed frequency with crop rotation (Tables 26-28). Annual grasses were less important (lower relative frequency) and annual broad-leaved species more important in mixed rotations than in continuous corn, regardless of tillage. Annual grasses were less important in mixed rotations than in perennial rotations in systems that involved some tillage. Perennials, especially quack grass, were more frequent in rotations that involved a perennial crop, regardless of tillage. Dandelions were more frequent in perennial and continuous corn rotations than in mixed annual rotations.

Annual grasses were found at greater densities in continuous corn rotations than in other rotations, regardless of tillage system (Table 29). Perennial weeds occurred at greater densities in no-till fields, regardless of rotation, but this trend was greater in continuous corn or if the rotation included a perennial crop.

The average number of species per field varied in a very narrow range for all of the management variables examined (Table 30). The trend was for fewer species with conventional tillage and more with no-till, but the range was only one species. The number of years in a tillage system showed no consistent trend. Winter wheat averaged over one weed species more than corn and soybean. This trend was more pronounced in conventional and conservation tillage than in no-till. Previous crop and rotation had little effect on average number of species per field.

Farmers in different areas were faced with different weed populations. In many instances, the geographic differences had a greater effect on weed populations than the management factors. Some species, such as green foxtail

(Figure 6), lamb's-quarters (Figure 7) and redroot pigweed (Figure 9) were found frequently throughout the surveyed area. Others, such as crab grasses (Figure 14), barnyard grass (Figure 17), yellow foxtail (Figure 20), witch grass (Figure 21), broad-leaved plantain (Figure 24), fall panicum (Figure 26), prostrate knotweed (Figure 27), field horsetail (Figure 28), Canada thistle (Figure 29), and wild carrot (Figure 30) were found in relatively low frequency throughout the surveyed area. Only a very few species had distribution patterns that suggest the factors limiting their success. Velvetleaf (Figure 13) and black nightshade (Figure 25) have frequency distributions that suggest relatively recent introduction in the extreme southwest, and subsequent limited expansion. Wild buckwheat (Figure 15) shows a distinct gradient from more frequent in the north to less frequent in the south of the surveyed area. Common yellow wood-sorrel (Figure 23) shows a similar gradient from northeast to southwest. Dandelion (Figure 11) was especially abundant in the east of the surveyed area. This may reflect the greater incidence of dairy farms in this area, and the corresponding increase in rotations with perennial crops. Field bindweed (Figure 16) and common milkweed (Figure 18) have similar patterns, with highest frequncies in Perth, Huron and Middlesex counties. Quack grass (Figure 8), common ragweed (Figure 10), annual smartweeds (Figure 12), yellow nut sedge (Figure 19), and chickweed (Figure 22), have distinct patterns that are not easily explained.

The average total weed densities for the counties varied from 16 plants/m^2 in Oxford to 37 plants/m^2 in Waterloo (Table 31). No distributional trend was evident for the total density or for the densities of any weed groups.

The average number of species per field varied among counties (Table 32), but again, no trend in distribution was evident. Some fields had no weeds in the surveyed quadrats and some fields had as many as 16 species.

The frequencies of species, the densities of weed groups and the number of species per field varied among soil families and soil texture (Tables 33-38), but no distributional trends were evident. For instance, the average total density for soil type varied from 6 plants/m^2 on Brady soils to 46 plants/m^2 on Berrien soils. These two soil families were both sandy loams.

Conclusion

There is an overwhelming perception that reducing tillage will be impractical in terms of weed control. This is not the overall conclusion of the current study. Weed populations were highly variable. The range of variation was as great within a tillage system as among them. Some conservation and no-till fields were very weedy; some were very clean. The same was true of conventional fields. The weed community reflects a combination of factors including the region, the soil, the cropping history, the cultivational history, and the skill of the farm manager. The change from conventional tillage to conservation or no-till did not lead to markedly different weed communites, at least not in terms of the weed community that remained after all control practices had been utilized. The residual weed community was largely unchanged, though final overall weed densities were somewhat larger with less tillage.

III. QUESTIONNAIRE SURVEY

Sampling Procedure

A questionnaire was completed for each field that was surveyed in each year. Questionnaires were completed by telephone interviews in 1988 and by either telephone or personal interviews in 1989. The questionnaire requested information on crop history, tillage history, and herbicide use.

Data analysis

All the information on the questionnaire was numerically coded and entered for computer processing. The responses to the questions were processed using several procedures of the SAS® Software System (SAS Institute Inc., Cary, NC).

Limitations of questionnaire survey information

The weed survey fields were selected to cover different tillage systems in three crops and in specific counties. The data can be used to examine differences in farm management practices associated with tillage differences. As the numbers of fields in various other categories is not representative of the amount of the surveyed area in those categories, the data cannot be generalized to the survey area as a whole without some indication of the proportion of the survey area that receives each type of tillage.

Questionnaire Survey Tables

Table 39. Number of fields for each rotation and tillage system

Rotation	Conventional	Conservation	No-till
Corn, bean, and cereal	80	104	96
Continuous corn	9	13	11
Continuous bean	0	4	4
Corn and bean	19	60	37
Corn and cereal	11	11	8
Beans and cereal	11	13	13
Perennial crops included	30	15	20
Other crops included	3	15	3

Table 40. Crop grown the year previous to the surveyed crop for each tillage system expressed as number of fields surveyed

	Crop grown the year previous			
Tillage system and crop	Corn	Bean	Cereal	Others
Conventional				
Corn	37	14	13	11
Soybean	48	8	13	1
Winter wheat	5	7	5	1
Conservation				
Corn	38	30	22	5
Soybean	42	22	14	0
Winter wheat	9	40	7	1
No-till				
Corn	26	29	16	4
Soybean	47	17	7	1
Winter wheat	7	33	1	5

Table 41. Percentage of corn, soybean, and winter wheat fields under conventional management using various implements after harvest of the last crop and prior to planting

Implement	Corn	Soybean	Winter wheat
Moldboard plow	100	100	100
Cultivator	81	74	72
Disc	9	10	17
Mulcher	3	1	6
Triple K cultivator	4	9	0
Cultipacker	4	4	0
Harrow	9	3	0
Leveller	1	3	0

Table 42. Number of corn, soybean, and winter wheat fields under conventional management using various combinations of implements prior to planting (including the previous fall for corn and soybean fields)

Implement combination	Corn	Soybean	Winter wheat
One type of implement			
Moldboard plow	1	7	1
Two types of implements			
Plow, cultivator	53	46	13
Plow, disc	4	2	3
Plow, cultipacker	2	1	0
Plow, mulcher	2	0	1
Plow, harrows	2	0	0
Plow, triple K cultivator	2	3	0
Plow, leveler	0	1	1
Three types of implements			
Plow, disc, cultivator	2	1	0
Plow, cultivator, harrows	4	1	0
Plow, leveler, harrows	0	1	0
Plow, triple K cult., leveler	1	0	0
Plow, cultivator, cultipacker	1	2	0
Plow, disc, triple K cultivator	0	3	0
Plow, cultivator, mulcher	0	1	0
Four types of implements			
Plow, disc, cultivator, harrows	1	0	0

Table 43. Percentage of corn, soybean, and winter wheat fields under conservation management using various implements after harvest of the last crop and prior to planting

Implement	Corn	Soybean	Winter wheat
Cultivator	56	65	53
Disc	36	41	40
Soil saver	27	21	5
Chisel plow	16	16	2
Mulcher	13	11	2
Airway	5	1	5
Triple K cultivator	4	5	5
Ridger	3	1	-
Paraplow	2	4	2
Cultipacker	1	1	2
Harrow	1	4	2
Packer	1	0	0
Prong point plow	0	1	0

Table 44. Number of corn, soybean, and winter wheat fields under conservation management using various combinations of implements prior to planting (including the previous fall for corn and soybean fields)

Implement combination	Corn	Soybean	Winter wheat
One type of implement			
Disc	12	11	15
Cultivator	15	13	27
Soil saver	1	2	0
Mulcher	7	2	1
Chisel plow	0	0	1
Triple K cultivator	2	2	2
Airway	3	1	3
Ridger	1	1	0
Paraplow	2	0	1
Two types of implements			
Disc, mulcher	0	1	0
Disc, cultivator	5	10	3
Disc, triple K cultivator	1	1	1
Disc, airway	2	0	0
Disc, ridger	1	0	0
Cultivater, harrow	0	2	0
Cultivator, ridger	1	0	0
Soil saver, cultivator	13	10	1
Soil saver, disc	6	1	2
Mulcher, cultivator	4	3	0
Chisel plow, disc	3	2	0
Chisel plow, cultivator	6	7	0
Chisel plow, triple K cult.	1	1	0
Chisel plow, mulcher	2	1	0
Prong point plow, cultivator	1	0	0

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Implement combination	Corn	Soybean	Winter wheat
Three types of implements			
Disc, harrows, ridger	0	1	0
Disc, cultivator, harrows	0	0	1
Soil saver, disc, cultipacker	0	1	1
Soil saver, mulcher, cultivator	0	1	0
Soil saver, disc, cultivator	3	1	0
Chisel, cultivator, harrows	1	0	0
Chisel, disc, ridger	1	0	0
Chisel, mulcher, cultivator	0	1	0
Chisel, soil saver, cultivator	2	0	0
Chisel, disc, culticator	0	1	0
Prong point, disc, cultivator	0	1	0
Paraplow, disc, cultivator	0	1	0
Four types of implements			
Soil saver, disc, cultivator, ridger	0	1	0
Soil saver, disc, cultivator, cultipacker			

Table 45. Implement use on corn fields under conventional, conservation, and no-till management

	Conventional	Conservation	No-till
Number of fields surveyed	75	97	75
Mean number of implement passes prior to planting, including the previous fall	3.0	2.1	0
Maximum number of implement passes prior to planting, including the previous fall	5	5	0
Mean number of implement passes after planting	0.7	0.6	0.2
Maximum number of implement passes after planting	2	3	2
Percentage of fields that were mechanically weeded after planting	53	41	19
Percentage of fields using			
one type of implement prior to planting, including previous fall	1	44	0
two types of implements prior to planting, including previous fall	87	48	0
three types of implements prior to planting, including previous fall	11	7	0
four types of implements prior to planting, including previous fall	1	1	0

Table 46. Implement use on soybean fields under conventional, conservation, and no-till management

	Conventional	Conservation	No-till
Number of fields surveyed	70	80	72
Mean number of implement passes prior to planting, including the previous fall	2.8	2.3	0
Maximum number of implement passes prior to planting, including the previous fall	5	6	0
Mean number of implement passes after planting	0.5	0.6	0.2
Maximum number of implement passes after planting	3	3	3
Percentage of fields that were mechanically weeded after planting	39	35	19
Percentage of fields using			
one type of implement prior to planting, including previous fall	10	40	0
two types of implements prior to planting, including previous fall	76	49	0
three types of implements prior to planting, including previous fall	14	10	0
four types of implements prior to planting, including previous fall	0	1	0

Table 47. Implements used on winter wheat fields under conventional, conservation, and no-till management

	Conventional	Conservation	No-till
Number of fields surveyed	18	58	46
Mean number of implement passes prior to planting, including the previous fall	2.8	1.6	0
Maximum number of implement passes prior to planting, including the previous fall	3	5	0
Percentage of fields using			
one type of implement prior to planting, including previous fall	6	86	0
two types of implements prior to planting, including previous fall	94	10	0
three types of implements prior to planting, including previous fall	0	4	0
four types of implements prior to planting, including previous fall	0	0	0

Table 48. Percentage of corn and soybean fields under conventional management that were mechanically or manually weeded

Implement	Corn	Soybean
Interrow cultivator	39	16
Scuffler	13	18
Rotary hoe	3	7
Harrows	0	1
Manually weeded	0	1

Table 49. Percentage of corn and soybean fields under conservation management that were mechanically or manually weeded

Implement	Corn	Soybean
Interrow cultivator	34	15
Scuffler	7	11
Rotary hoe	4	11
Manually weeded	4	10

Table 50. Percentage of corn and soybean fields under no-till management that were mechanically or manually weeded

Implement	Corn	Soybean
Interrow cultivator	19	18
Rotary hoe	0	1
Manually weeded	9	11

Table 51. Percentage of the corn, soybean, and winter wheat fields treated with various fall applied, burndown, preplant, preemergence, split application, and postemergence herbicides

Category and herbicide	Number of fields	Corn	Soybean	Winter Wheat
Broad-leaved				
Dicamba	148	57	<1	5
2,4-D or 2,4-DB	105	24	12	15
Bentazon	73	3	29	0
MCPA or MCPB	51	5	0	31
Bromoxynil	30	11	<1	1
Mecoprop	18	5	0	4
Cloroxuron	4	0	2	0
Grassy				
Metolachlor	257	52	58	0
Sethoxydim	28	0	13	0
EPTC	13	5	0	0
Fenoxaprop-ethyl	13	0	6	0
Fluazifop-butyl	5	0	2	0
Butylate	3	1	0	0
Broad-leaved and grassy				
Atrazine	139	56	<1	0
Metribuzin	115	4	47	0
Linuron	79	1	34	0
Cyanazine	34	14	0	0
Ethalfluralin	13	0	6	0
Trifluralin	11	0	5	0
Metobromuron	5	0	2	0
Ethalfluralin	3	0	1	1
Monolinuron	2	0	1	0
Non-selective				
Glyphosate	185	34	39	11
Paraquat	1	<1	0	0
Other (not registered)	13	2	3	1
Not treated	65	1	2	47

Table 52. Herbicide use on corn fields under conventional, conservation, and no-till management

	Conventional	Conservation	No-till
Number of fields surveyed	75	96	75
Number of fields not treated	2	0	0
Mean number of herbicides used per treated field (exluding spot treatments)	2.1	2.4	2.7
Mean number of spot treatments used per treated field	0.1	0.3	0.5
Maximum number of herbicides used per treated field (including spot treatments)	5	5	7
Percentage of the herbicides			
applied prior to planting[1]	29	23	26
applied preemergence	44	33	35
applied postemergence	23	32	22
applied as spot treatment	4	12	17

[1] This category included previous fall, burndown, and preplant applications.

Table 53. Herbicide use on soybean fields under conventional, conservation, and no-till management

	Conventional	Conservation	No-till
Number of fields surveyed	70	80	73
Number of fields not treated	1	2	1
Mean number of herbicides used per treated field, excluding spot treatments	2.3	2.2	2.7
Mean number of spot treatments used per treated field	0.2	0.3	0.6
Maximum number of herbicides used per treated field, including spot treatments	5	5	7
Percentage of the herbicides			
applied prior to planting[1]	27	31	30
applied preemergence	49	41	35
applied postemergence	16	16	16
applied as spot treatment	9	12	19

[1]This category included previous fall, burndown, and preplant applications.

Table 54. Percentage of corn fields under conventional, conservation, and no-till management treated with various herbicides

Type of application	Herbicide	Conventional	Conservation	No-till
Prior to planting[1]	Atrazine	27	27	23
	Glyphosate	11	16	33
	Metolachlor	9	11	7
	2,4-D or 2,4-DB	0	3	17
	EPTC	5	8	0
	All others	9	4	5
Preemergence	Metolachlor	37	36	47
	Dicamba	33	24	31
	Atrazine	12	19	15
	Cyanazine	8	7	13
	All others	4	5	15
Postemergence	Dicamba	12	27	25
	Atrazine	13	19	15
	2,4-D or 2,4-DB	3	13	16
	Bromoxynil	8	8	5
	MCPA or MCPB	5	5	4
	Cyanazine	1	5	5
	All others	4	10	4
Spot[2]	Glyphosate	4	6	35
	2,4-D or 2,4-DB	0	7	7
	Mecoprop	0	6	4
	Dicamba	0	6	4
	All others	5	6	8

[1]This category included previous fall, burndown, and preplant applications.
[2]Spot treatments included applications at all times of the year.

Table 55. Percentage of soybean fields under conventional, conservation, and no-till management treated with various herbicides

Type of application	Herbicide	Conventional	Conservation	No-till
Prior to planting[1]	Glyphosate	6	11	36
	Metolachlor	18	22	10
	Metribuzin	20	17	14
	2,4-D or 2,4-DB	0	2	25
	Ethalfluralin	10	7	0
	Trifluralin	6	7	0
	All others	7	4	6
Preemergence	Metolachlor	46	36	42
	Linuron	31	31	31
	Metribuzin	38	25	25
	All others	4	4	10
Postemergence	Bentazon	18	19	18
	Sethoxydim	7	7	17
	Fenoxaprop-ethyl	4	5	4
	All others	8	7	10
Spot[2]	Glyphosate	15	14	32
	Bentazon	4	9	15
	All others	1	6	11

[1]This category included fall, burndown, and preplant applications.

[2]Spot treatments included applications at all times of the year.

Table 56. Herbicide use on winter wheat fields under conventional, conservation, and no-till management.

	Conventional	Conservation	No-till
Number of fields surveyed	18	59	46
Number of fields not treated	9	29	20
Mean number of herbicides used per treated field, excluding spot treatments	1.0	1.5	1.2
Mean number of spot applications used per treated field	0	0.1	0.1
Maximum number of herbicides used per treated field, including spot treatments	1	4	2
Percentage of the herbicides			
applied prior to planting[1]	22	6	23
applied preemergence	0	0	0
applied postemergence	78	87	70
applied as spot treatment	0	7	7

[1]This category included burndown and preplant applications.

Table 57. Percentage of winter wheat fields under conventional, conservation, and no-till management treated with various herbicides

Type of application	Herbicide	Conventional	Conservation	No-till
Postemergence	MCPA or MCPB	33	36	24
	2,4-D or 2,4-DB	6	15	20
	Dicamba	0	8	2
	Mecoprop	0	8	0

Discussion of the Questionnaire Results

Crop history

Cropping histories were similar for different management systems. A rotation of corn, soybean and cereal was most common for all management systems (Table 39). Cereal crops were more often a part of the rotation in conventional tillage than in either conservation or no-till systems; a corn-bean rotation was more common in conservation or no-till than in conventional management. Conservation tillage systems were less likely to incorporate a perennial crop into the rotational sequence.

Corn followed corn more frequently in conservation and conventional systems than in no-till and corn followed bean less frequently in conventional management than in either conservation or no-till systems (Table 40). Winter wheat generally followed soybean in conservation or no-till systems; winter wheat followed a variety of crops in conventional systems.

Tillage history

Conventional tillage, by definition in this study, included soil inversion by moldboard plow. Conventional tillage also included the use of a cultivator in a majority of fields (Tables 41, 42).

In conservation tillage, the cultivator remained an important tillage tool (Table 43), but a variety of other tillage treatments were also used: disc, soil saver, chisel plow and mulcher (Table 44). Fewer tillage implements were used prior to winter wheat than prior to corn or soybean.

In all three crops, conservation tillage involved a reduction in the number of tillage passes prior to planting and a reduction in the number of tillage implements used (Tables 45, 46 and 47).

In-crop tillage was common in corn in both conventional and conservation management (Tables 48, 49). The interrow cultivator was the most common implement used. In-crop tillage occurred to a lesser degree in soybean in all management systems, and in no-till corn (Table 50). Hand weeding was more common in conservation soybean and in both corn and soybean under no-till management.

Herbicide use

More than half of the corn fields examined received dicamba, atrazine and/or metolachlor. Glyphosate and 2,4-D or 2,4-DB were also important

herbicides in corn production (Table 51). Metolachlor, metribuzin, glyphosate, linuron and bentazon were important in soybean production. The most common procedure for winter wheat was to use no herbicide treatment. MCPA or MCPB were used most commonly in the winter wheat fields that received a herbicide treatment.

Herbicide applications were similar in all three management systems. Fields in no-till corn or soybean received more herbicides per treated fields than conventionally managed fields of these crops (Tables 52, 53), but the increases were very slight (less than one per field, on average). There was no real change in the general timing of herbicide application in these crops, except that spot treatments were fewer in conventional tillage.

In corn fields, dicamba, atrazine and 2,4-D or 2,4-DB were more commonly used as postemergent treatments in conservation tillage or no-till, relative to conventional tillage. Glyphosate and 2,4-D or 2,4-DB were more commonly used prior to planting (burndown) or as spot treatments in no-till systems (Table 54).

In soybean fields, conventional and conservation systems generally used the same products at the same times (Table 55). In no-till systems, there was again an increase in the use of glyphosate and 2,4-D or 2,4-DB prior to planting (burndown) or as spot treatments. The use of other herbicides prior to planting was reduced in no-tillage; the use of other herbicides as spot treatments was increased. Sethoxydim was used more commonly in no-till systems than in either conservation or conventional systems.

Herbicide use in winter wheat fields was much less than in corn or soybean fields, and was again similar in all management systems (Table 56). The proportion of winter wheat fields that received MCPA or MCPB was similar in all three management systems (Table 57). The use of other chemicals was minor in all management systems, but was least in conventional tillage.

Conclusion

In this study, management systems were defined by tillage type. These management systems varied a great deal in cropping history, herbicide use, and in the finer details of tillage, even within a tillage category. Differences among the management systems were slight, and do not indicate that large-scale changes in weed problems were associated with the management systems.

Appendix of Field Survey Summary Tables

Guide For The Use Of The Field Survey Summary Tables

For the purposes of illustration, the meaning of the various terms will be explained for the species green foxtail in the summary table for all fields surveyed during 1988 and 1989 (see Table A1 in Appendix). The **frequency** value of 47.7% indicates that green foxtail occurred at least once in 283 of the 593 fields surveyed. The value does not indicate how often the weed occurred in the 20 quadrats in each of the fields.

The value for **field uniformity** does, however, indicate the proportion of quadrats (20 per field) in which the species occurred. In the example, the value for **all field uniformity** indicates that green foxtail occurred in 14.2% of all the quadrats surveyed (20 per field for 593 fields). The occurrence field uniformity value indicates that green foxtail was present in 29.7% of the quadrats for the occurrence fields only (20 per field for 283 fields).

Two **field density** values are given. The density for fields in which the species occurred is always equal or higher than the density for all the fields in the summary. Green foxtail had an **occurrence field density** of 10.5 plants per square metre and an **all field density** of 5.0 plants per square metre. The **density range** indicates that at least one of the 283 fields had a density of 0.2 green foxtail plants per square metre and at least one of the 283 fields had a density of 211.2 green foxtail plants per square metre.

The final column indicates the **relative abundance** of each of the species surveyed, relative to each other. The values in this column add up to 300. Relative abundance is derived from the frequency, all field uniformity, and all field density values. This relative abundance parameter is used as a means of ranking species such as lamb's-quarters and quack grass which have different frequencies and all field uniformity values but have similar all density values. Lamb's-quarters is ranked above quack grass because both the frequency and all field density values are higher. The values of 32.9 for lamb's-quarters and 29.6 for quack grass indicate the relative abundance of the two species. Green foxtail has a relative abundance of 41.8 and is more abundant than lamb's-quarters or quack grass.

Tables A1-A69 (pp. 107-239)